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Long recognized as a reliable source of accurate information on the electronic industries, the annual ***Electronic Market Data Book*** *contains detailed information on production, sales, foreign trade, R&D, and U.S. government markets. Covering the many diverse products of the electronic industries, the* ***1992 Electronic Market Data Book*** *is based on the data provided to EIA by several hundred companies, supplemented by selected government and private sources. Some of the data contained in this publication is available free or for a nominal fee from the Federal Government.*

A glossary of terms appears at the back of the book for convenient definitions of acronyms and government/electronic terminology discussed in the text of the publication.

Researching, compiling, tabulating, writing, editing, and producing an annual statistical yearbook requires a dedicated and hard working team. I would like to greatly acknowledge the contributions of the following EIA staff in preparing the core content of the ***1992 Electronic Market Data Book:***

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Please feel free to contribute YOUR suggestions for the ***1993 Electronic Market Data Book***.

Laurie Adler
Editor

Foreword

Whatever the issue, EIA's primary objective is to eradicate the barriers to an efficient and productive marketplace. EIA's *1992 Electronic Market Data Book* is one vehicle which offers excellent, detailed insight into the exciting, hi-tech electronics market. EIA is proud to be a leader in the movement towards a more efficient U.S. market. We realize that the future of the U.S. electronics industry rests increasingly on our ability to forge working alliances with complimentary industries and to nurture our most promising technologies. An example is our recent work with the recording industry to successfully put digital audio broadcasting within the reach of U.S. consumers.

Whether it is gathering global market data on such products as capacitors and resistors, leading the charge for a more rational export policy in telecommunications and other areas, sponsoring showcase events for products as diverse as the latest in consumer electronics or surface mount technologies or standing up for the preservation of our defense industrial base, the EIA is ever vigilant in promoting the growth and technological progress of electronic manufacturers in the United States.

This new edition of the **Electronic Market Data Book** contains a wide range of data on one of our country's largest and most vital industries. The electronics industry is the source for much of the productivity improvement in our economy and the innovation which touches and enhances our lives. We invite you to browse the pages of this book, to see for yourself the significance of the electronics industry to our nation's economy and to the enjoyment of life for each of us.

Francis J. Myers

Francis J. Myers
Chairman, EIA Board of Governors
Chairman of the Board and CEO
Wells-Gardner Electronics Corp.

The U.S. electronics industry produces thousands of products, ranging from photoelectronic semiconductors, to high-powered laptop computers. These products provide the means to dramatically increase worker productivity, thus providing value far beyond their cost. The U.S. electronics industry is also a major supplier of high-tech products to the world. Using constant exchange rates, the U.S. share of worldwide production of electronics is virtually unchanged from 1984 to 1991.

The continued stength of exports was the 1991 highlight for the U.S. electronics industry. Electronic exports totaled $71.6 billion, a gain of 7% over 1990. Since 1982, total exports have grown at a compound annual rate of 12.8%. The importance of the world market to the U.S. electronics industry should never be underestimated. In 1991, 33% of the value of electronics manufactured in the U.S. were exported, responsible for 100% of the growth in the total U.S. electronics industry in 1991.

As was the case for many U.S. industries, the U.S. electronics industry suffered through the 1991 recession. Although the total industry had historically slow growth in 1991, there were strong performances turned in by the telecommunications and electromedical sectors.

To maintain its prominent place in the world market, the U.S. electronics industry is staying on the cutting edge. Recent data on the Top-200 electronics companies in the U.S. illustrate this. These companies annually spend more than 5% of their sales revenue on research and development.

As we look forward to 1992 and beyond, we can anticipate great advances and achievements from the electronics industry. Products and concepts such as multimedia, high-definition television and virtual reality have the power to transform not only the electronics industry, but also the life of every person on the planet. The Electronic Industries Association is proudly devoted to making this bright future a reality.

Peter F. McCloskey

Peter F. McCloskey
President, Electronic Industries Association

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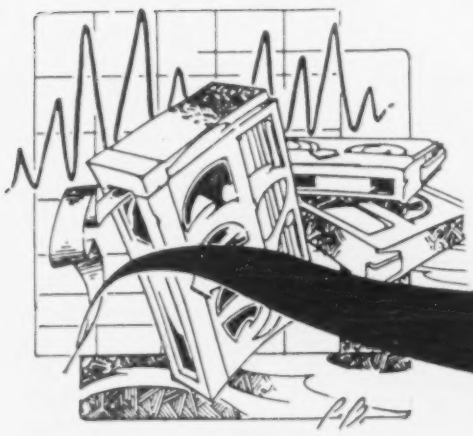

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ECONOMIC AND INDUSTRY OVERVIEW

THE ECONOMIC CLIMATE

The year 1991 was a rocky one for the U.S. economy. Real gross domestic product (GDP) declined at an average annual rate of 0.7% in 1991, ending eight consecutive years of economic growth. A number of problems plagued the U.S. economy in 1991. A lack of consumer confidence, depressed real estate markets, and anemic growth in real earnings were just some of the negative forces at work. All of these problems, combined with the high debt burdens faced by federal and state governments, as well as consumers and corporations, forced marked reductions in consumption. The cutbacks were reflected in two important measures: industrial production in the nation's factories and mines declined 1.8% in 1991, while the real value of personal consumption expenditures (PCE) on goods and services declined 0.1%. The decline in PCE was matched by a 0.1% decline in real disposable income in 1991.

While there were many economic negatives in 1991, there were some positive signs. Inflation at both the wholesale and consumer levels remained in check. Prices of wholesale goods (excluding food and energy) rose just 3.1% in 1991, while a 3.1% increase was also seen in retail prices, as measured by the consumer price index (CPI). Foreign trade continued to have a buoying effect on the U.S. economy in 1991. Merchandise exports totaled $421.6 billion in 1991, up 7% from $393.9 billion in 1991.

There is reason for some optimism in 1992 according to forecasts published in the *Blue Chip* Economic Consensus. For all of 1992, the *Blue Chip* panel expects real growth in GDP of 1.6%. The group also expects retail prices to remain under control, with a consensus forecast rise in the CPI of 3.2%.

ELECTRONIC INDUSTRIES OVERVIEW

The total value of the U.S. electronic industries increased 1.5% in 1991 to $271.4 billion. This historically slow growth high-

Selected U.S. Economic Data, 1982-1992 TABLE I

YEAR	REAL GDP[1]	REAL PCE[2]	CPI ALL ITEMS[3]	INDUSTRIAL PRODUCTION[4]	GOVERNMENT PURCHASES[5]
1982	3,760.3	2,503.7	96.5	81.9	723.6
1983	3,906.6	2,618.4	99.6	84.9	743.8
1984	4,148.5	2,746.1	103.9	92.8	766.9
1985	4,279.8	2,865.8	107.6	94.4	813.4
1986	4,404.5	2,969.1	109.6	95.3	855.4
1987	4,540.0	3,052.2	113.6	100.0	881.5
1988	4,718.6	3,162.4	118.3	105.4	886.8
1989	4,836.9	3,223.1	124.0	108.1	900.4
1990	4,884.9	3,262.6	130.7	109.0	929.1
1991	4,848.8	3,259.0	136.2	107.0	937.1
1992e	4,926.4	3,311.1	140.5	109.3	941.8

NOTES:
[1]Gross Domestic Product in billions of 1987 dollars.
[2]Personal Consumption Expenditures in billions of 1987 dollars.
[3]Consumer Price Index for Urban Consumers, All Items, 1982-1984 = 100
[4]Index of total Industrial Production, 1987 = 100
[5]Total federal, state and local government purchases of goods and services in billions of 1987 dollars.

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U.S. Factory Sales of Electronics by Industry Group ($ Million); 1982-1991

TABLE II

Year	Electronic Components	U.S.-Produced Consumer Electronics[1]	Telecommunications Equipment	Other Communications	Computers & Peripheral Equipment	Industrial Electronics	Electromedical Equipment	Other Related Products and Services[2]	Total
1982	29,561	6,369	20,150	19,012	34,764	16,473	4,402	na	130,731[r]
1983	33,856	5,895	20,777	21,342	38,709	16,531	4,845	na	141,954[r]
1984	43,306	7,092	26,009	24,342	48,355	20,388	5,148	31,009	205,649[r]
1985	39,459	6,110	29,208	28,627	49,444	20,121	5,028	35,266	213,262[r]
1986	38,829	6,517	29,085	31,396	48,215	20,286	4,931	39,117	218,375[r]
1987	45,335	6,373	29,910	33,087	52,840	21,325	5,576	41,166	235,612[r]
1988	50,989	7,483	31,113	33,241	54,136	22,100	6,015	45,398	250,475[r]
1989[r]	56,380	8,152	31,589	32,842	54,194	24,798	6,339	45,914	260,208
1990[r]	55,094	8,115	33,109	34,134	53,268	24,960	7,010	51,571	267,261
1991[e]	55,974	9,057	35,161	32,249	52,382	24,336	7,535	54,684	271,378

[1]Includes U.S.-produced audio, video, blank media products, and electronic toys. Refer to Table 1-1 for total sales of consumer electronics products including imports.
[2]Includes EIA estimate of the electronic content of aerospace and automotive equipment, and selected computer software and services.
Totals may not add due to rounding.
na-Not Available.
r-Revised.
e-Estimated.

lights the fact that even industries as innovative & dynamic as electronics are not immune to recessionary pressures.

Growth in U.S. factory sales in 1991 was led by telecommunications equipment. Sales in this sector rose 6.1% to $35.2 billion. Growth in the components sector mirrored growth in the overall industry, rising 1.6% to $56 billion. Sales of electromedical equipment totaled $7.5 billion in 1991, a gain of 7.5%, while sales of domestically-produced consumer electronics products grew 11.6% to $9.1 billion. Factory sales and receipts of other related products and services totaled an estimated $54.7 billion in 1991. An estimated $41.7 billion of electronic sales were to the defense industry in 1991.

Three sectors posted annual declines in 1991, the largest being the computer & peripherals industry. Despite the fact that factory prices of computers fell in excess of 20% in 1991, this sector posted sales of $52.4 billion, down just 1.7% from 1990. Sales in the industrial electronics sector, hampered by the slow pace of capital spending, fell 2.5% to $24.3 billion. Cutbacks in defense spending were the cause of the decline in sales of other communications equipment. This sector, which is composed primarily of high-tech military equipment, posted sales of $32.2 billion in 1991, a drop of 5.5%.

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Introduction

Electronics has been called the most influential technology of the 20th century, and much of its impact is yet to come.

Radio and television, computers, satellites, factory automation, space flight, and sophisticated defense systems are all made possible by electronics. With recent developments in microelectronics technology, allowing hundreds of thousands of electronic circuits to be imprinted on a dime-sized chip of silicon, electronics is now facilitating the everyday functions of banks, supermarkets, kitchens, mail delivery, and offices of every kind. Pick up your phone, start your car, turn on the news, or read a clock and you are in touch with the electronics revolution. During the remainder of this century, electronics will have a pervasive and long-lasting influence on international trade, employment, communications, industrial productivity, entertainment, and our entire way of living.

Electronics is defined as the branch of science and technology that deals with the study, application, and control of the conduction of electricity in a vacuum, gas, liquid, semiconductor, conductor, or superconductor. Electronic products contain material, parts, components, subassemblies, and equipment which employ the principles of electronics in performing their major functions. The ability to influence the flow of electricity distinguishes electronic equipment from that which is merely electrical.

HISTORY

The control of electrons was first achieved in 1883, when Thomas Edison induced electrons to jump across the partial vacuum between a carbon filament and a metal plate in his light bulb. In 1897, the electron was discovered in England by Sir Joseph John Thomson. Electronic communications—the transfer of information from one place to another in the form of electronic circuits—began in 1894 when Oliver Lodge developed a system of wireless communications in England. Around the turn of the century, considerable progress in wireless telegraphy was made by Guglielmo Marconi, Ernest Rutherford, and others. The invention of the three-element vacuum tube by Lee De Forest in 1906 made possible the development of radio broadcasting and the practical application of television.

The usefulness of wireless communications in saving many lives from the Titanic in 1912 and during World War I demonstrated to the United States the importance of being a world leader in developing this technology. Between 1910 and 1920, rapid progress was made in the theory, application, and construction of vacuum tubes and other electric components such as capacitors and resistors. Following the introduction of ground-to-aircraft radio communications during World War I, radio broadcasting stations began operating throughout the United States.

Radio sets were first sold to the public in 1920. The earliest industry statistics show that 100,000 radios were sold in 1922 at an average factory value of $50 each, and in the same year 1 million electron tubes were sold at an average price of $6 each. In 1924, a handful of manufacturers gathered in Chicago to form the Radio Manufacturers Association (RMA), which later became the Electronic Industries Association (EIA). By this time, annual factory sales of radios had jumped to $50 million. An estimated 750 new firms entered the industry between 1923 and 1926, taking advantage of the rapidly expanding market and the fact that relatively little capital or trained labor was needed to manufacture radios.

In 1926, President Coolidge referred to the invention of radio as "one of the most wonderful incidents in the advance of civilization," and told RMA that the Government "stands ready to do what may be done to encourage the development of radio."

In the years to follow, the industry was plagued by such problems as overproduction and patent infringement suits. Consumer preference for well-known brands began to develop, and by 1934, only about 40 U.S. firms remained in the industry. The absence of technical standards presented what was perhaps the industry' greatest problem, and the creation of standardized procedures by the RMA was considered its most significant contribution to the rapid development of radio broadcasting and the eventual introduction of television, FM radio, and other broadcast services.

Although radio manufacturers were hit by the financial failures and low profits of the Depression era, the need for entertainment amidst widespread unemployment made the 1930s the golden years of radio. The years prior to World War II also saw technical progress in many areas, including the development of television, radar, oscilloscopes, voltmeters, and electromechanical analog calculators and computers.

Although television and FM radio were first authorized in 1941, civilian production of electronic products was suspended within a few months after Pearl Harbor, and the radio

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industry converted its plants and manpower to production of military equipment for communications, detection, surveillance, and guidance. The War Production Board reported that in 1941, factory sales of radios totaled $240 million, and by 1944, the radio and radar industry, including parts manufacturing, reached a peak production rate of $4.5 billion per year—a gain of 1,775%! With the stimulus of multi-million dollar R&D funding, electronics entered a period of extraordinary growth and innovation, leading to the production of sophisticated radar, sonar, testing, measuring, and flight control equipment. Giant calculators, the first form of digital computers, were perfected for use in high-speed data processing, automatic fire, navigation, and flight control.

The cessation of hostilities caused a sharp decline in electronics manufacturing from its wartime peak of 560,000 workers, but the post-war advent of large-scale television production resulted in another upward trend in employment. Also contributing to the post-war growth of consumer electronics was the development of high fidelity sound, FM sound, and the first tape recorders. Sales of radio equipment were superseded by the advent of television, the increasing application of electronics to industrial uses, and expanding military markets.

Wartime research also contributed to a technological breakthrough that transformed the electronic industries: the invention of the transistor, announced by Bell Laboratories in 1947. A transistor consists of semiconducting material—usually silicon—to which minute quantities of impurities have been added, causing it to conduct electricity and perform switching and first used in hearing aids and military products, this tiny, ultra-reliable substitute for the electron tube proved ideal for computers and consumer products. Electronics was soon to become dominated by semiconductor technology.

The laborious, time-consuming process of assembling components into electrical equipment, the growing number of transistors used as switching devices in computer and other digital equipment, and the increasing complexity of circuits eventually led to the next, inevitable breakthrough in electronics: fabricating transistors and other components such as capacitors and resistors from a quarter-inch-square piece of silicon. The integrated circuit (IC) was born in 1959, and produced in mass quantities by 1962.

The growth of the semiconductor industry was made possible by large orders from the U.S. Department of Defense for integrated circuits used in military equipment in the late 1960s. This led to huge increases in production, resulting in rapid price decreases which made semiconductors cost-effective for many consumer, industrial, and commercial applications. This also helped to stimulate growth of digital computer technology and markets.

It soon became feasible to combine thousands of circuits into a single silicon chip, in a technique known as large-scale integration (LSI). During the past two decades, phenomenal increases in the number of circuits that can be imprinted on a chip have been accompanied by huge reductions in cost and energy consumption. By the end of the 1970s, the United States was selling over $6 billion worth of semiconductors annually to world-wide markets, and the advanced industrial nations were racing to develop "very large-scale integration" (VLSI), in which hundreds of thousands of circuits are etched onto a chip using lithography of micrometer line widths.

Since most of the time and expense needed to produce ICs comes at the design stage, the use of special chips for particular applications has often been discouraged by the complexity of the design required. This has fostered the development of the microprocessor, in which the entire central processing unit of a computer—the complex circuitry that processes information and carries out computations—is contained on a silicon chip. Because its software can be altered to fit a variety of applications, the microprocessor can be incorporated relatively cheaply into a wide range of products and systems from cruise missiles to children's toys.

The growth of electronics has thus been built on the development of circuits, from the vacuum tube to the transistor to the integrated circuits. While the phenomenal potential of semiconductor technology has only begun to be realized, ongoing research in VLSI, optical circuitry, superconduction, and other technologies may soon lead to yet another era in electronics technology.

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1 Consumer Electronics

The consumer electronics industry swept into the decade of the 1980s on a technological tidal wave that brought with it a new generation of entertainment, educational, and commercial products and systems—many made possible by the tiny microprocessor chip. The tidal wave has continued into the 1990s as more products and systems, which impact Americans' lives and lifestyles, are introduced. Products such as interactive television, multimedia computing, digital compact cassette recorders, and others continue to change and fine-tune the home entertainment, communication and educational possibilities available in the United States and the world.

Representing an estimated $47 billion in U.S. retail value last year, major consumer electronic categories include: **Video**—televisions, videocassette recorders, laserdisc players, camcorders, and satellite earth stations; **Audio**—compact disc

Factory Sales of Consumer Electronic Products (Including Imports) ($ Million); United States, 1982-1991 TABLE 1-1

CATEGORY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Color TV Receivers, incl. LCD	4,253	5,002	5,538	5,565	6,040	6,292r	6,121r	6,824r	6,576r	6,581
Projection TV	236	268	385	488	530	527	524r	494r	640r	715
TV/VCR Combinations	—	—	—	—	—	—	—	—	178	266
Monochrome TV Receivers, incl. LCD	507	465	419	328	373	341	202r	156	132	92
VCR Decks	1,303	2,162	3,585	4,173r	3,978	3,442	2,786r	2,638r	2,438r	2,475
Camcoders[1]	—	—	—	565r	1,279	1,651	1,983r	1,994r	2,260	2,024
Color Cameras	232	303	355	228	59	na	na	na	na	na
Laserdisc Players	54	81	45	23	26	26	34	50	72	82
Videocassette Players	—	—	—	—	—	—	57	63	65	71
Audio Systems	573	630	976	1,372	1,370	1,048	1,225	1,217	1,270	1,264
Separate Audio Components	1,181	1,268	913	1,132	1,358	1,715	1,854	1,871	1,935	1,805
Home Radios	530	565	661	379	408	409	377	379	360	310
Portable Tape & CD Player Equipment[2]	971	1,102	1,191	1,140	1,389	1,469	1,547	1,596	1,645	1,780
Autosound Equipment	2,100	1,900	2,500	2,761	3,135	3,523	3,937	4,125	4,292	4,108
Blank Audio Cassettes	202	234	256	270	300	375	367	384	376	373
Blank Videocassettes	280r	486r	771	1,055	1,235	1,006	936	923	948	980
Blank Flexible Diskettes	—	—	—	—	—	—	258	297	314	357
Accessories[3]	—	—	—	—	—	748	2,417	2,204	2,322	2,291
Total	12,422r	14,466r	17,595	19,479	21,480	22,572r	24,625r	25,215r	25,823r	25,574
Estimates by Consensus[4]	1,810	3,065	3,780	5,822	6,058	6,440	7,338r	8,594r	9,825r	10,468
GRAND TOTAL	14,232r	17,531r	21,375	25,301	27,538	29,012r	31,963r	33,809r	35,648r	36,042

[1]Prior to 1985, data included in VCR Decks.
[2]Prior to 1983, data exclude CD players.
[3]Prior to 1987, data included in Estimates by Consensus.
[4]Includes home satellite earth stations, home computers, telephone equipment, facsimile devices, electronic typewriters and home security systems. Prior to 1988, data reflect Videocassette Players. Prior to 1985, data reflect home computers and telephone equipment only.
r-Revised
SOURCE: EIA Marketing Services Department.

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players, components, systems, compact and personal units, tape equipment, radios, and car audio; **Home Information Equipment**—home computers, electronic typewriters, personal copiers, facsimile machines, calculators, software, telephones, telephone answering devices, and handheld references products; **Accessories**—for video, audio, home information equipment and all other consumer electronics; **Home Automation Products**—universal remote controls; **Assistive Devices**—hardware and software that assist individuals with disabilities, including electronic health care products; and **Personal Electronics**—watches, electronic games and toys, security systems, appliances, and musical instruments.

In the area of video, current technology is emphasizing the steady emergence of advanced television and new uses for the television screen. Digital hi-fi and multi-channel sound for video are sparking a renewed surge of interest in audio, and leading to the integration of audio and video in products such as the new laserdisc combi-players, which play both compact audio discs and laser video discs.

The complex combinations of audio and video are perhaps best demonstrated by the increasingly popular home theater concept. The combination of multi-dimensional surround sound and theater-quality video creates truly amazing home entertainment unlike any previously possible.

In the area of audio, digital audio is setting higher standards for sound quality and reproduction than ever before. The trend continues towards multi-room systems and secondary systems in rooms other than the main home entertainment listening or viewing room.

Personal computers, video games, facsimile machines, and personal handheld reference devices have also drastically altered the way millions of Americans spend their working and leisure hours. The 1990s has already seen the introduction of multi-use products which combine business and entertainment functions. These include products such as handheld video game products which also serve as electronic spell-checkers and language translators.

Accessory items and new types of software continue to enhance the enjoyment and utility potential of all consumer electronics product categories for millions of users. Assistive devices of all kinds are enabling people with functional limitations to enjoy more full and productive lives.

Unit sales to retailers of such items as color televisions, camcorders, compact disc players, cellular telephones, and telephone answering devices set new all-time records in 1991, resulting in an overall U.S. factory sales value of approximately $36 billion, with an estimated value of $47 billion at retail. A 2.8% growth rate is expected for factory sales in 1992, bringing the total to just over $37 billion.

CONSUMER ELECTRONICS—ITS ORIGIN AND HISTORY

The consumer electronics industry is now well into its second half-century and has entered a period of unparalleled innovation. It took shape as an industry in 1920, when radio broadcasting started in the United States and the first radio receiving sets were offered to the public. It was then known as the radio industry, and the word 'electronics' was not to come into common use for another 25 years. But 'cat's whisker,' 'crystal set,' 'earphones,' and 'B-battery' became bywords with those who were captivated by this miraculous advance in home entertainment.

By 1922, radio was more than a fad, and the earliest statistics by what is now called the Electronic Industries Association (EIA), show that 100,000 radios were sold that year at a factory value of $5 million—an average of $50 each. When EIA's predecessor association was organized two years later as the Radio Manufacturers Association (RMA), the annual factory volume of radios had multiplied tenfold to $50 million.

Origins In 1877

Many earlier landmarks contributed to the birth of consumer electronics. Perhaps the most significant were Edison's 1877 invention of the phonograph, Fleming's development of the electron tube in the 1890s, Marconi's first wireless transmission in 1895, and DeForest's 1906 inventions which led to the electronic amplifier.

Radio might not have been an instant success if Americans had not been conditioned to living room sound entertainment by the phonograph, which was already more than 40 years old when it was joined by the radio in the front parlor. At first a purely mechanical-acoustical device, the phonograph later entered the consumer electronics family by marriage to the radio—its sound box replaced by electronic amplification, its spring drive by an electric motor.

The period from 1920 until the United States entry into World War II in 1941 was the age of radio, in which 100 million receivers were sold (less than the number sold in 1972 and 1973 alone). During this time came such dynamic innovations as the loudspeaker, the superheterodyne circuit, the line-cord radio, the automobile radio, and the portable set, which operated both from AC and battery.

Mobilization and War

Although television and FM radio were initially authorized in 1941, their popularization did not begin until after World War II. All civilian production was suspended during the war, when the radio industry turned its attention to electronic devices for communication, detection, surveillance, and guidance.

Under the pressure of wartime requirements, the 'radio industry' grew in both sophistication and size. After resumption of civilian production late in 1945, it was ready to satisfy a huge pent-up demand for radios and phonographs, and to launch a wave of new products which still shows no signs of abating.

VIDEO EQUIPMENT

The Transformation—From TV To Video

A transformation which is both evolutionary and revolutionary is underway — changing not only the nature of the con-

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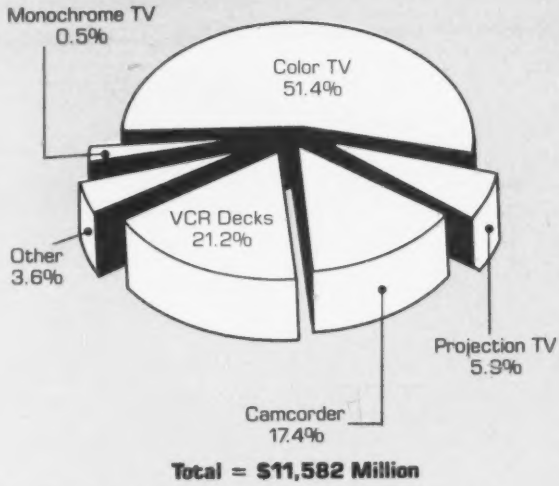
sumer electronics industry but the American home and the American lifestyle. The key word is 'video'—and the changes involve our basic sources of information, entertainment, education, and communication. The video revolution, with its potential effects, has already been compared to the automobile revolution of the early 20th Century.

For many years, the conventional television set served one purpose—the reception and reproduction of broadcast programs. Community antenna TV (CATV) systems, which augmented the choice of broadcasts and improved reception, evolved into today's cable TV, which now may provide up to 100 channels or more of entertainment, information, and service. To basic cable was added premium service or pay television. Similar services—including broadcast subscription TV and microwave-delivered pay TV—were added in areas where cable had yet to penetrate. Other new program sources began to proliferate. Suddenly the television screen became an all-purpose display device, an audio/visual nerve center of the home, as programming evolved from an economy of scarcity to one of abundance.

Video games let viewers interact with their screens for the first time. Videocassette recorders (VCRs) let viewers rearrange time and create their own program viewing schedule. Along with VCR decks, laserdisc players provide access to broad new choices of programs to augment 'real time' broadcast and cable transmissions. Camcorders have replaced film cameras for home movie making and are creating a generation of 'do-it-yourself' program producers.

Distribution of Factory Sales of Video Equipment by Type (%); United States, 1991 FIGURE 1-A



Total = $11,582 Million

SOURCE: Table 1-1.

Color Television

The many new video products and their uses are important contributors to the strong demand for color television (TV) receivers, year after year. Manufacturers and distributors have sold more than 20 million direct-view color TVs, including TV/VCR combinations, in each of the last four years. This is a remarkable record, considering 98% of all American TV homes already own at least one color set, and more than 60% have two or more. A steady demand from buyers seeking to replace or upgrade existing color TVs, and from those seeking an extra set for the bedroom, den or kitchen, helps keep sales at a high level. The *EIA Video Retail Buying Rate Survey* indicates that replacement and additional set purchases account for more than 90% of all color TV sales.

Big-screen direct-view color TVs with 27-inch to 35-inch picture tubes were a growth area in 1991, a year in which overall color TV sales experienced a slight decline. In a con-

Factory Production[1] of Television Receivers (Thousands of Units and Dollars); United States, 1982-1991 TABLE 1-2

YEAR	MONOCHROME		COLOR		TOTAL MONOCHROME AND COLOR	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	4,922	437,000	11,484	4,288,000	16,406	4,725,000
1983	5,647	459,000	14,034	5,047,000	19,681	5,506,000
1984	5,194	431,000	17,190	5,896,000	22,384	6,327,000
1985	3,620	304,000	16,905	5,629,000	20,525	5,933,000
1986	3,975	330,000	19,010	6,268,000	22,985	6,598,000
1987	3,650	296,000	19,847	6,470,000	23,497	6,766,000
1988	2,365	149,000	20,147	5,923,000	22,512	6,072,000
1989	1,720	120,000	23,139	5,919,000	24,859	7,039,000
1990	1,425	100,000	20,840	6,335,000	22,265	6,435,000
1991	na	na	20,118	6,204,000	20,118	6,204,000

na-Not available.
[1]Includes domestic production and imports.
SOURCE: EIA Marketing Services Department.

Annual Factory Production[1] of Color Television Receivers by Type (Thousands of Units and % of Total); United States, 1982-1991 TABLE 1-3

YEAR	PORTABLE & TABLE		CONSOLE		TV/VCR COMBINATIONS		TOTAL UNITS
	UNITS	% OF TOTAL	UNITS	% OF TOTAL	UNITS	% OF TOTAL	
1982	9,102	79.3	2,382	20.7			11,484
1983	11,221	80.0	2,813	20.0			14,034
1984	13,977	81.3	3,213	18.7			17,190
1985	14,087	83.3	2,818	16.7			16,905
1986	15,964	84.0	3,046	16.0			19,010
1987	17,292	87.1	2,555	12.9			19,847
1988	17,826	88.5	2,321	11.5			20,147
1989	20,863	90.2	2,276	9.8			23,139
1990	18,525	88.9	1,829	8.8	486	2.3	20,840
1991	17,969	89.3	1,495	7.4	654	3.3	20,118

[1]Includes domestic production and imports.
SOURCE: EIA Marketing Services Department

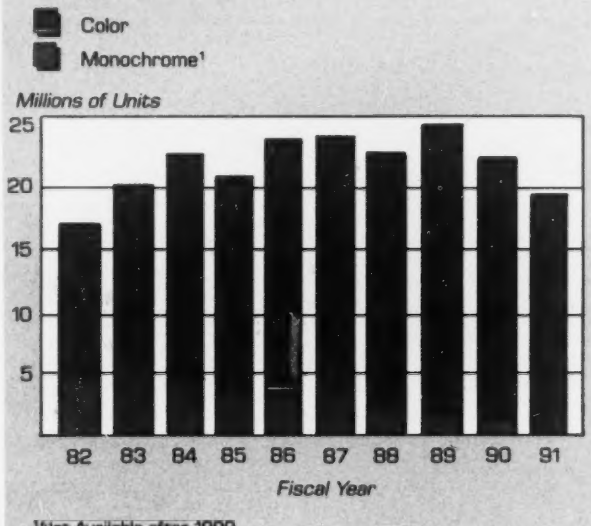
tinuing trend, table models in the screen size range of 25-inch and over outsold consoles in 1991. The 20-inch table model was the industry's best seller in 1991, followed by the 19-inch table model. Market demand also continued strong for 13-14 inch and 27-29 inch table models. This year, manufacturers will be offering a wider variety of models of big-screen color TVs, and will be putting even more emphasis on models with improved resolution for sharper, more detailed pictures.

Remote control, once a relatively expensive step-up feature, is virtually standard now on all big-tube table and console color TV models. It is included on the majority of 19-inch and 20-inch sets manufactured today, and is also available on smaller screen TVs. Along with the growth of remote control there has been an increase in the number of new color TVs using quartz-synthesized computer tuning, making possible random-access selection of a wide variety of channels.

With more than 60% of all TV homes hooked into cable TV systems, manufacturers now offer color sets which are cable-compatible. These sets can tune in a varying number of non-scrambled cable channels without the use of external converters. This tuning feature makes it possible to use the TV set's remote control features with cable TV. It can also save money for those served by cable systems offering a reduced monthly rate to subscribers who do not need a converter box. The majority of sets sold last year were so equipped.

The trend to personal portable consumer electronics has extended to color television. Pocketable receivers with 2-inch and 3-inch liquid crystal displays (LCDs) are generally available in the market. Advances in LCD know-how have made it possible to offer pocket TVs that provide resolution and color fidelity approaching that of conventional picture tubes. Prototype portable and desktop LCD color TVs in larger sizes ranging from 7-inch up to 14-inch have been shown, and some could enter the market in 1992. Many in the industry feel that advances in LCD and other display technologies will eventually lead to the introduction of large, flat, wall-hung color TV displays.

Annual Factory Production of Television Receivers by Type (Millions of Units); United States, 1982-1991 FIGURE 1-B



[1]Not Available after 1990
SOURCE: Table 1-4.

Advanced Television

With the application of digital signal processing technology to the home receiver, the age of advanced TV has begun. The United States is leading the world in advanced television systems, with several digital transmission systems under review. High-Definition TV (HDTV), when it arrives, will bring with it true double-resolution TV displays, nearly equal in quality to that of 35mm film, plus top quality digital stereo sound.

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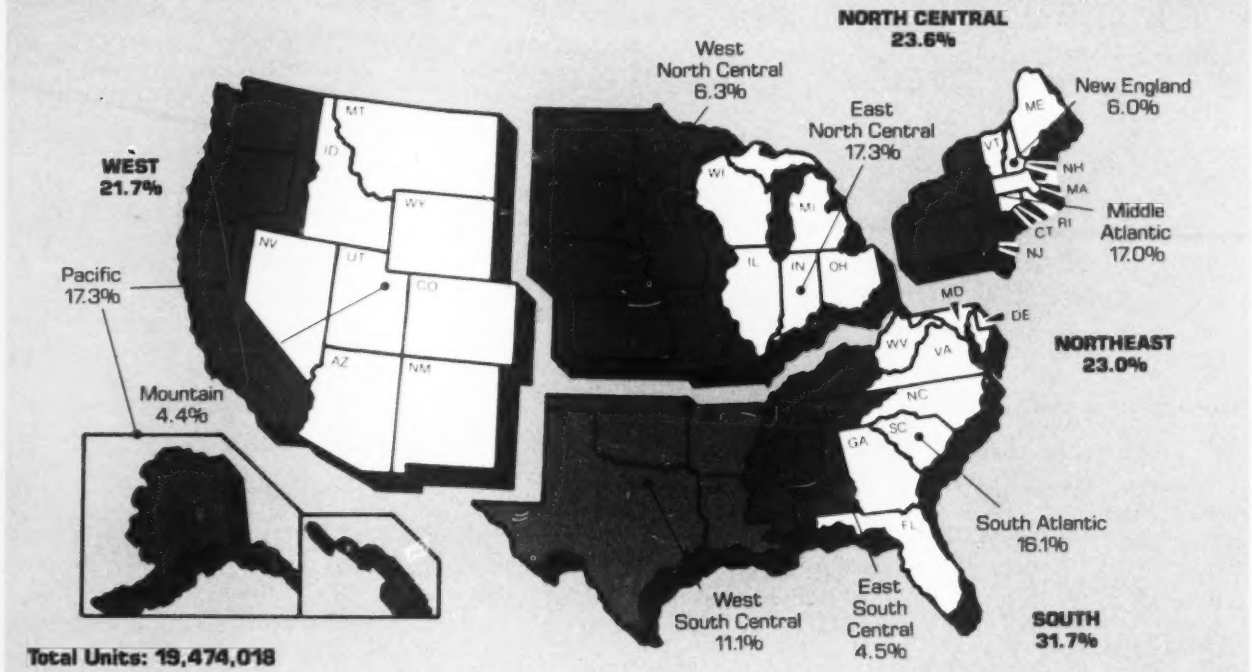
Estimated Total Sales to Dealers of Color Television Receivers by Region (%); United States, 1991[1] FIGURE1-C



Total Units: 19,474,018

[1]Excludes institutional.

The FCC's decision on a suitable U.S. standard for HDTV broadcasting will be based on a recommendation by its Advisory Committee on Advanced Television Service. Testing on the various systems began in 1991 at the $15 million-plus Advanced Television Test Center, a laboratory financed by the major television networks, the cable industry, and the EIA.

The Sound of Stereo Comes To TV

The metamorphosis from television to video is also seeing a new emphasis on a sometimes neglected link in the TV chain—audio. While the move to improve sound quality started several years ago, it was given a strong boost in 1984 when the Federal Communications Commission approved the start of stereo audio broadcasts by TV stations. Though the FCC did not specify a standard, the EIA Multichannel TV Sound Subcommittee recommended a system.

All commercial TV networks, the Public Broadcasting System, and most local TV stations and satellite transmissions now feature stereo audio on regularly scheduled and special broadcasts. Virtually all U.S. TV homes are within reach of a TV signal with stereo audio. In addition, nearly all cable TV systems are supplying stereo to their subscribers.

While overall sales of direct-view color TVs were off slightly in 1991, sales of stereo-equipped sets enjoyed a seventh straight year of double-digit increases. The stereo feature was included in a record 37% of all color TVs sold in 1991, exceeding industry expectations. It is anticipated that the penetration level will rise again in 1992. Stereo is now virtually a standard feature in big-tube, direct-view, and projection TVs, and is found in a steadily growing percentage of home VCR decks. The number of broadcast, cable, and satellite TV programs being transmitted with stereo audio are also on the increase.

The EIA system provides for more than just binaural audio. An important aspect is a third, alternative, sound channel called Second Audio Program (SAP). While broadcasters can use the SAP for any purpose, in areas with large ethnic populations stations are using it for bilingual broadcasts, which help bring millions of non-English-speaking citizens into the mainstream of American television. Alternatively, SAP can allow for separate novice and professional commentaries during televised sports events; give the viewer of a foreign film a choice between the original or English dubbed soundtrack; or add descriptive commentary for the visually impaired.

Many of the new stereo TV receivers come with stereo audio amplifiers and speakers. Most have audio output jacks to permit the sound to be fed to a separate hi-fi system. SAP-only models that offer the viewer a choice between the regular (monaural) audio or the SAP audio signal are also available. In addition, surround sound that fills a room with three-dimensional sound quality has been introduced, further enhancing the marriage of video and audio. (For further information see the Audio section of this chapter.)

There are add-on options for consumers who want to enjoy TV stereo audio but are not ready to purchase a new color

Factory Sales[1] of Television Receivers (Thousands of Units and Dollars); United States, 1982-1991

TABLE 1-4

YEAR	MONOCHROME		COLOR		TOTAL MONOCHROME AND COLOR	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	5,692	506,881	11,673	4,252,951	17,365	4,759,832
1983	5,735	464,535	14,310	5,001,996	20,045	5,466,531
1984	5,050	419,150	16,563	5,537,659	21,613	5,956,809
1985	3,684	309,456	17,145	5,562,398	20,829	5,871,854
1986	3,953	328,099	18,768	6,024,624	22,721	6,352,723
1987	3,547	287,307	19,753	6,271,419	23,300	6,558,726
1988	2,574	162,162	20,886	6,090,812	23,460	6,252,974
1989	1,656	115,920	23,013	6,783,842	24,669	6,899,762
1990	1,411	98,770	21,654	6,525,688	23,065	6,624,458
1991	784	61,134	21,211	6,525,362	21,995	6,586,496

[1]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
SOURCE: EIA Marketing Services Department.

TV. Complete TV stereo audio tuners are also available. Some receive TV audio only; others also tune FM and AM radio. Some of them come complete with a stereo audio amplifier and speaker; others are intended for use with separate audio systems. Stereo audio for TV is not a new concept—millions of viewers have enjoyed stereo audio from videocassettes, videodiscs, and 'simulcast' programs for which the stereo audio portion can be taken from cable or picked up by an FM radio.

Monochrome TV

Despite the popularity of color TV, there is still a demand for black-and-white models. Last year, more than 780 million conventional tube type, and more than 500,000 pocketable sets with liquid crystal displays, were sold to retailers. In table models, the dominating screen size is 12-inch, and many are designed for either AC or 12-volt operation, so they can be used on boats, trailers, and recreational vehicles. Small-screen battery portables, including models with flat tube and liquid crystal displays, account for more than 50% of the industry sales volume. Small-screen combos, which include a radio and/or audio cassette recorder, are helping bolster the popularity of B&W TVs. Many home nighttables and office desks now hold a compact B&W TV/AM-FM clock radio combination.

Projection TV

Giant-screen projection color TV is an important part of the video industry product spectrum, and virtually every major TV manufacturer features at least one model. In 1991, sales

Factory Sales[1] of Color Television Receivers by Type (Thousands of Units and Dollars); United States, 1982-1991

TABLE 1-5

YEAR	PORTABLE & TABLE		CONSOLE		TV/VCR COMBINATIONS		TOTAL	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	9,207	2,958,301	2,466	1,294,650			11,673	4,252,951
1983	11,424	3,518,592	2,886	1,483,404			14,310	5,001,996
1984	13,453	3,995,335	3,110	1,542,324			16,563	5,537,659
1985	14,163	4,163,780	2,982	1,398,618			17,145	5,562,398
1986	15,835	4,607,985	2,933	1,416,639			18,768	6,024,624
1987	17,225	5,012,475	2,528	1,258,944			19,753	6,271,419
1988	18,410	4,860,240	2,476	1,230,572			20,886	6,090,812
1989	20,839	5,709,886	2,174	1,073,956			23,013	6,783,842
1990	19,235	5,366,565	1,994	981,048	425	178,075	21,654	6,525,688
1991	19,023	5,440,534	1,526	819,218	662	265,610	21,211	6,525,362

[1]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
SOURCE: EIA Marketing Services Department.

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Sales to Dealers[1] of Television Receivers (Thousands of Units), United States, 1982-1991

TABLE 1-6

YEAR	MONOCHROME	COLOR	TOTAL MONOCHROME AND COLOR
1982	5,765	11,366	17,131
1983	5,697	13,986	19,683
1984	4,909	16,083	20,992
1985	3,754	16,995	20,749
1986	3,959	18,204	22,163
1987	3,570	19,330	22,900
1988	2,580	20,216	22,796
1989	1,656	21,706	23,362
1990	1,411	20,808	22,219
1991	784	20,136	20,920

[1]Includes distributor sales and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department.

Sales to Dealers[1] of Color Television Receivers by Type (Thousands of Units and % of Total); United States, 1982-1991

TABLE 1-7

YEAR	PORTABLE & TABLE		CONSOLE		TV/VCR COMBINATIONS		TOTAL UNITS
	UNITS	% OF TOTAL	UNITS	% OF TOTAL	UNITS	% OF TOTAL	
1982	8,904	78.6	2,426	21.4			11,330
1983	11,179	79.9	2,807	20.1			13,986
1984	13,092	81.4	2,991	18.6			16,083
1985	13,993	82.3	3,002	17.7			16,995
1986	15,399	84.6	2,805	15.4			18,204
1987	16,805	86.9	2,525	13.1			19,330
1988	17,768	87.9	2,448	12.1			20,216
1989	19,557	90.1	2,149	9.9			21,706
1990	18,453	88.7	1,931	9.3	424	2.0	20,808
1991	17,951	89.1	1,523	7.6	662	3.3	20,136

[1]Includes distributor sales and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Stereo Color Television Receivers (Units and % of Total); United States, 1987-1991

TABLE 1-8

YEAR	STEREO UNITS	STEREO % OF TOTAL COLOR TV FACTORY SALES
1987	4,349,078	22.5%
1988	5,090,425	25.2%
1989	6,043,397	27.8%
1990	6,655,193	32.0%
1991	7,377,221	36.6%

[1]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
SOURCE: EIA Marketing Services Department.

of projection sets hit an all-time high of 389,280 units, an impressive achievement considering the growing consumer demand for giant-tube direct-view color models.

While pricing has fluctuated over the years, projection TVs are still quite expensive, due to the utilization of high cost precision optics and special electronic display systems. New configurations and styles of projection television are making these systems more acceptable in a great number of American homes. There are currently three major types of projection TV, with screen sizes from about 35 inches to more than 10 feet in diagonal measurement. Two-piece units employ separate screens and projector-receivers. One-piece front-projection systems have foldout or hinged drawers containing the picture source, keeping the cabinet relatively compact when the TV is not in use. Single-piece rear-projection units have translucent screens which display the picture projected from the inside of the cabinet.

While improvements in conventional three-tube front and rear projection TVs continue to be made, a new system of

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Production and Sales of Projection Televisions (Units); United States, 1982-1991 TABLE 1-9

YEAR	FACTORY PRODUCTION[1]	FACTORY SALES[2]	SALES TO DEALERS[3]
1982	126,705	118,110	117,253
1983	114,314	140,807	143,506
1984	217,142	204,463	195,194
1985	278,971	269,436	265,645
1986	342,167	307,794	304,272
1987	314,358	299,902	293,084
1988	276,596	299,995	301,784
1989	288,766	274,242	265,300
1990	281,574	358,638	351,402
1991	389,280	397,878	379,837

[1]Includes domestic production and imports.
[2]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
[3]Includes distributor sales and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department.

Factory Sales[1] of Projection Televisions (Thousands of Units and Dollars); United States, 1982-1991 TABLE 1-10

YEAR	UNITS	DOLLARS
1982	118	235,748
1983	141	267,686
1984	204	385,356
1985	269	487,697
1986	308	529,760
1987	300	526,500
1988	300	523,800
1989	274	494,022
1990	359	640,456
1991	398	715,385

[1]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
SOURCE: EIA Marketing Services Department.

generating giant-screen displays has recently debuted. Long in development, and now a reality, are color video projectors that use liquid crystal displays as light valves. Compactness is the hallmark of this new generation of video projectors. The largest take up no more table-top space than a 19-inch TV and can be stored in a cabinet when not in use. The smallest battery portable models can be slipped into a briefcase. LCD projectors use high brightness bulbs as a light source and are adjustable to throw a 3-foot to 10-foot display on an ordinary movie screen, or even a white wall. Technical limitations on the number of individual picture elements, or pixels, limit the image resolution. However, advances in that area are rapidly being made. Current LCD projectors are premium-priced, and therefore they mainly appeal to business users and the most upscale consumers. Over the next several years, however, increased volume and lower costs should see LCD projection TVs become price competitive with conventional models.

Wide-Screen TV On The Way

U.S. consumers will not have to wait for the arrival of HDTV to enjoy the panoramic-like pictures of wide-screen color TV in their homes. The first color TVs with 16:9 aspect ratio picture tubes are scheduled to be on the U.S. market before the end of 1992.

Already on sale in Europe and Japan, the initial models will have 34-inch diagonal displays, and a picture height about equal to that of today's conventional 27-inch models. These feature-loaded color sets will have line-doubling for sharper images, picture-in-picture displays, stereo, and of course, remote control. In addition, they will be designed to accept adaptors for the reception and display of true HDTV signals.

A broad array of wide-screen programming is already available in the form of so-called letter-boxed films and special material on pre-recorded videodiscs and videocassettes. When shown on standard 4:3 aspect ratio color TVs, letter-boxed programs fill about 60% of the screen height, and have black bars across the top and bottom. They fill the entire display on wide-screen TVs. Most movies are filmed in wide screen and have to be converted for TV, a process that eliminates all but the central portion of the on-screen action. Letter-boxing allows for movies to be shown on TV just as they were in theaters. Some directors consider the impact of wide-screen so important to their films, they only permit video release in letter box.

Equipment manufacturers are now working with video companies, cable programmers, and broadcasters to increase the use of letter-boxing, and have begun marketing camcorders, which record in either 4:3 or 16:9. This enables consumers to create their own wide-screen material.

Home Theater Systems

The arrival of high quality, large-screen color TVs, plus stereo audio, has launched a new video market phenomena—the home theater experience. The impact of the enhanced sight and sound available from video equipment today can approximate the entertainment atmosphere that until now could only be found in the most modern movie theaters. Recreating the basics of a theater at home requires a larger-tube TV equipped with hi-fi quality stereo sound capability. A more advanced set-up would include a stereo direct-view or projection TV with a built-in surround sound decoder and extra speakers for the rear audio channels. Alternatives to broadcast or cable programming are provided by adding a videocassette recorder, laserdisc player, or video game.

The complete home theater system would include the TV display, one or more alternate video program sources, plus hi-fi audio components centered around an audio/video receiver. A/V receivers contain stereo AM/FM tuners, a stereo amplifier and input/output jacks for unified control of all of the video

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Factory Sales[1] of Videocassette Recorders (Thousands of Units and Dollars);[2] United States, 1982-1991 TABLE 1-11

YEAR	VCR DECKS		PORTABLE		CAMCORDERS[3]	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982						
1983	3,374	1,576,370	753	585,939		
1984	6,966	2,897,856	915	687,165		
1985	10,683	3,771,133	586	402,155	517	565,268
1986	12,167	3,893,440	167	85,003	1,199	1,279,333
1987	11,627	3,441,592	*	*	1,604	1,650,516
1988	10,676	2,786,436	*	*	2,057	1,982,948
1989	9,805	2,637,545	*	*	2,271	1,993,938
1990	10,117	2,438,197	*	*	2,962	2,260,006
1991	10,809	2,475,294	*	*	2,879	2,023,967

[1]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
[2]Unit and dollar figures for decks and portable not available prior to 1982.
[3]Camcoders included in "portable" prior to 1985.
*Portable included in VCR Decks.
SOURCE: EIA Marketing Services Department.

and audio feeds to the TV and external speakers. Some A/V receivers also have surround sound decoders and four-channel amplifiers.

Many manufacturers offer a variety of complete packaged systems, along with the cabinetry needed to house them. Alternatively, consumers can visit a different type of retailer, one specializing in custom home theater installations. System pricing ranges from several hundred dollars to several thousand, depending on the features and quality levels of the included components. Most one-brand systems offer a unified remote control, a single hand-held unit that operates all of the performance and switching features of all the components in the system. Purchasers of multi-brand or custom installed systems can enjoy the same single-unit control by adding one of the multi-product programmable or pre-programmed remotes being offered as an accessory by a number of manufacturers.

Videocassette Recorders And Players

The first major new in-home video program source for the television receiver since the advent of cable TV was the videocassette recorder (VCR), introduced in 1975. It is estimated that nearly 77% of all U.S. TV households now also contain a VCR. But, as is the case with color TV, there is strong demand from second-time buyers who are seeking replacements or are adding a second or even a third VCR model to their collection of consumer electronics. Upgrading as a purchase incentive is shown by the fact that the unit sales growth in the last two years all came from step-up models, offering such features as hi-fi stereo and four-head special effects play-back performance. Sales are expected to continue strong well into the future due to a rapidly growing market for replacement VCRs among consumers who purchased sets in the start-up years, and the development of a demand for second and even third VCRs in homes.

Most home VCRs in use now conform to either the Beta or VHS standard and use half-inch tape in easy-to-load cassettes. VCRs designed to the 8mm format, which uses a cassette about the same size as a standard audio cassette and tape just eight millimeters (about a quarter-inch) wide were first introduced in 1984. While the small cassette size makes the 8mm particularly suitable for portable applications, VCR decks in that format are available as well.

In all formats, even the most basic home models offer electronic tuner timers and such special effects as freeze-frame and visible forward and reverse picture scan. Optional step-up features include wireless remote control, variable slow

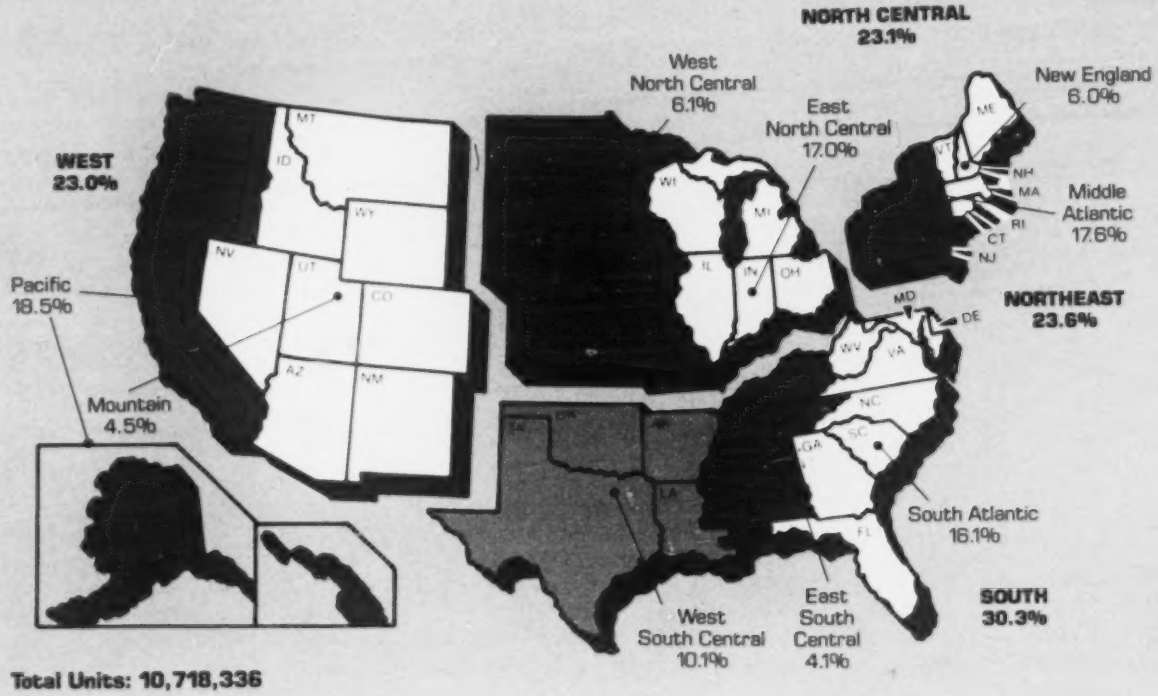
Imports of Videocassette Recorders[1] (Thousands of Units and Dollars); United States, 1982-1991 TABLE 1-12

YEAR	UNITS	DOLLARS[2]
1982	2,462	1,031,966
1983	4,760	1,605,771
1984	9,377	2,852,737
1985	16,262	4,165,103
1986	17,605	4,403,711
1987	13,305	2,895,846
1988	11,696	2,506,246
1989	16,401r	4,347,293r
1990	15,856	4,355,599
1991	17,646	4,763,433

r-Revised
[1]Includes recorder/players other than consumer-type.
[2]U.S. Customs Value.
SOURCE: U.S. Department of Commerce.

Estimated Total Sales to Dealers of VCR Decks by Region (%); United States, 1991

FIGURE 1-D



Total Units: 10,718,336

and fast motion, unscrambled cable channel reception, expanded programmability, and on-screen function display. The most technologically advanced models include digital solid state memories, for such special effects as picture-in-picture allowing simultaneous viewing of two program sources at once, freeze, variable slow motion, stored image recall, picture polarization, and multiple sequential stillframe display that can call up and continuously refresh images from all available

Factory Sales[1] of Blank Videocassettes[2] (Thousands of Units and Dollars); United States, 1982-1991

TABLE 1-13

	RETAIL DISTRIBUTION		INDUSTRIAL AND BULK DISTRIBUTION		TOTAL SALES	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	24,672	279,674	8,857	77,766	33,529	357,440
1983	60,368	485,926	14,635	94,516	75,003	580,442
1984	133,185	770,555	33,284	161,376	166,469	931,931
1985	233,021	1,054,825	60,638	229,704	293,659	1,284,529
1986	296,253	1,234,689	71,138	245,526	367,391	1,480,215
1987	273,830	1,005,916	46,585	142,788	320,415	1,148,704
1988	296,947	935,667	43,621	115,270	340,568	1,050,937
1989	285,571	923,071	51,099	126,977	336,670	1,050,048
1990	338,238	948,240	43,031	100,073	381,269	1,048,313
1991	362,122	979,630	36,126	78,560	398,248	1,058,190

[1]Includes factory sales to distributors and factory direct sales to dealers. Excludes sales to duplicators.
[2]Does not include 8mm, S-VHS, VHS-C, & S-VHS-C prior to 1988.
SOURCE: EIA Marketing Services Department.

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TV or cable channels. Decks are also available with jog shuttle frame selection dials and other special editing capabilities. New Super VHS and ED (Extended Definition) Beta models provide sharper, clearer pictures.

Standard home VHS decks capable of playing back cassettes recorded in the Super-VHS mode are now on the market, though not in full Super-VHS picture quality. This feature, which is expected to be more common as new models are introduced, is intended to encourage a gradual transition to a market where Super-VHS is the standard, making it economically practical for more software companies to release prerecorded cassettes in the Super-VHS mode. Another recent innovation is home VHS decks, which are designed to play smaller VHS-C cassettes without a cassette shell adaptor.

Full stereo audio playback, as well as the recording of stereo broadcast and cable TV programming, is offered by Beta, VHS Hi-Fi, and digital audio 8mm format home decks, which are also equipped with Multichannel TV Sound tuners. Helping boost consumer demand for stereo VCRs, in addition to the widening availability of stereo TV programming, is that most new movies released on pre-recorded video cassettes come with stereo sound tracks. It is estimated that about 23% of all VCR decks sold in 1991 included stereo as a feature, up from 21% in 1990.

A variation on the VCR is the videocassette player (VCP). Generally priced lower than full-function VCRs, VCPs appeal to existing VCR owners considering buying a second set, and to non-owners interested only in buying or renting prerecorded videocassettes.

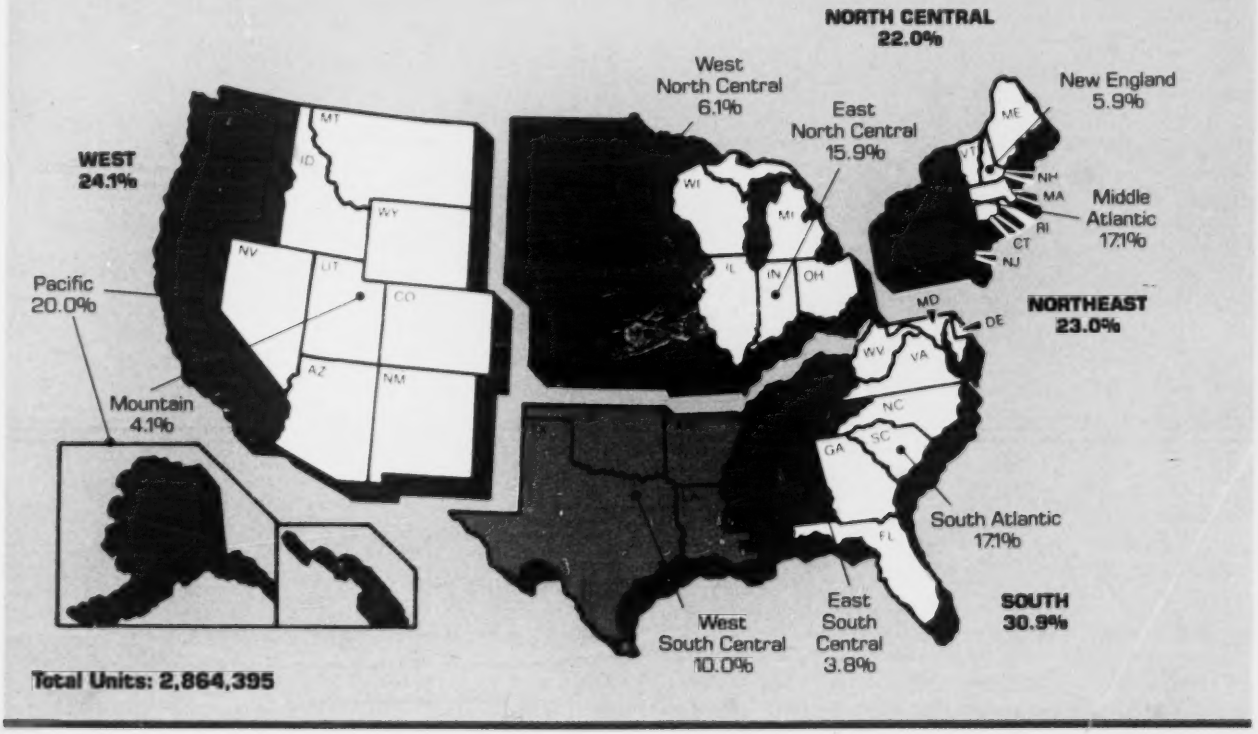
A rapidly growing option for consumers looking for a new TV or VCR is the color TV/VCR, a two-in-one space saving and user-friendly combination product. Sales to U.S. retailers of TV/VCRs jumped 56% to 662,400 last year, from 423,500 in 1990. The most popular models have 13-inch or 14-inch screens, and take up no more table-top space than their TV-only counterparts. Battery portables, with 5-to-7-inch screens, as well as larger table models, with 19-inch, 20-inch, and even 27-inch pictures, are also available. Some smaller models can be operated from 12-volt power sources, making them suitable for use in boats, campers, and recreational vehicles. Most offer remote control and include many of the same programming and convenience features found in stand alone VCR decks. TV/VCP combinations are also available.

Camcorders

The camcorder, a one-piece camera-VCR combination, has almost replaced two-piece portable VCR systems in the marketplace. Camcorders are available with such advanced features as power zoom, automatic focus, variable speed electronic shutters, interchangeable lenses, built-in tilting capability, and digital memories for a variety of special effects. In 1991, the industry sold nearly 2.9 million camcorders.

Camcorders are purchased primarily by consumers who already own home VCR decks and are interested in a simple-to-use, lightweight portable for electronic photography. Camcorders are available in all formats — full-sized VHS and Beta

Estimated Total Sales to Dealers of Camcorders by Region (%); United States, 1991 FIGURE1-E



Total Units: 2,864,395

Production and Sales of Camcorders (Thousands of Units); United States, 1986-1991 TABLE 1-14

YEAR	FACTORY PRODUCTION[1]	FACTORY SALES[2]	SALES TO DEALERS[3]
1986	1,245	1,199	1,169
1987	1,623	1,604	1,604
1988	2,309	2,057	2,044
1989	2,210	2,271	2,286
1990	2,746	2,962	2,962
1991	3,313	2,879	2,864

[1]Includes domestic production and imports.
[2]Includes factory sales to distributors and factory direct sales to dealers and factory export sales.
[3]Includes distributor sales and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department.

as well as the compact VHS-C and 8mm. New Super VHS, Super VHS-C, ED Beta, and High Band 8mm record and play back pictures with a horizontal resolution of between 400 and 450 lines, providing a picture quality that exceeds broadcast standards.

While camcorder sales slipped slightly in 1991, all the decline came in full-size VHS models, as sales of both VHS-C and 8mm models rose significantly—accounting for 68% of unit volume. This brought the U.S. sales mix more into line with that of the European and Far East markets, where compact camcorders have been the leading sellers for several years. Full-size VHS camcorders have the advantage of using cassettes that are directly compatible with most home VCRs. However, more and more, consumers are opting for compact models, as their smaller size and lighter weight make them easier to carry around to family gatherings and special events.

Personal Video

In much the same way that portable headphone tape players and radios opened a whole new world of personal audio, a new generation of portable, and even pocketable, personal video products are expected to create a new way of program viewing. Personal videos combine a VCR with a 3-inch to 4-inch color liquid crystal display for viewing on the go. Personal videos with full-size VHS and 8mm video format VCRs are already available, and models using VHS-C are expected to be introduced this year.

Personal videos are designed for AC, battery, or 12-volt operation and contain tuners so they can be used for watching and/or recording TV programs, as well as for viewing prerecorded material. While VCRs afford the opportunity of watching any program at any time, personal video products extend that advantage to include 'anywhere.'

Still Video Cameras

The newest development in video recording, the still video camera, is the snapshot equivalent of the camcorder. Just as the camcorder has all but replaced the 8mm film camera for home movie making, the still video camera is expected to become the still photography system of choice for large numbers of shutterbugs.

Still video cameras available for sale to consumers today use a 2-inch magnetic disk that can hold either 25 full-frame (525-line) or 50 field (reduced resolution) images. Some cameras can record sound in addition to pictures, enabling the user to include about 10 seconds of narration or sound effects with each image. A new generation of still video cameras, currently priced strictly for the professional market, store images on cards containing solid state memories.

The electronic, full-color snapshots can be played back through a TV. Some cameras have built-in playback capability; others require the use of an adapter. Still images can be transferred to videocassette to create home slide shows. The disks can be erased and reused.

Several manufacturers are offering separate disc recorder-players which are used for playback of multiple playback discs, as well as to capture still images from TV programs, videocassettes, or videodiscs. Another accessory permits the transmission of still images to a remote disc recorder over the telephone. Printers are also on the market which can produce a full color hard copy of the video snapshot. These can also be used to capture and print out a copy of a scene from any other video source.

Photo CD, a system that brings home video and 35mm film photography together, is slated for availability around mid-1992. Photo CDs are 5-inch optical laser discs which can digitally store up to 100 images copied from 35mm color slides by local photo finishers for playback on home TVs. The necessary special Photo CD players can also be used with standard audio-only CDs. In addition, software companies are planning to issue educational and entertainment programs on pre-recorded Photo CDs which can hold up to 800 images, or 72 minutes of audio, or a combination of the two.

Laserdisc Systems

The laserdisc player stores sound and images on a disc format and plays back sight-and-sound through a TV set or video monitor. The laserdisc is designed to be a relatively low-cost, high-quality video entertainment and educational medium. Disc players are simple to operate and offer random access to various program segments.

Players on the U.S. consumer market today use the light from a low-power solid state laser to read information encoded on the reflective surface of the disc. Multi-function models, currently the most popular players, are designed to handle conventional digital audio-only CDs as well as 12-inch and 8-inch videodiscs, plus 5-inch CD-Video discs. Their ability to provide full frequency digital stereo audio has made the disc players particularly attractive to opera, ballet, and classical music lovers. These players are also an important factor in the market for popular music video recordings.

Video Software

Today's video software market has grown in importance to essentially equal the hardware side of the industry. It is estimated that some 362 million blank videocassettes were sold to dealers last year. In addition, consumers are believed to

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have spent nearly $15 billion to rent and buy commercially pre-recorded videocassettes in 1991. Retailers offer recorded videocassettes and discs for both sale and rental. While feature films are the most popular form of recorded video, a vast new market has opened for specialty programs. These include music videos, children's shows, comedy specials, and games, as well as educational and instructional tapes on health, exercise, travel, sports, and home and car repair.

Captioning

The evolution of television took another major step forward in 1990 when Congress passed, and the President signed into law, a bill mandating the inclusion of closed-caption decoders in all color sets with screens of 13-inch or larger which are manufactured or imported after July 1, 1993. In 1991 the FCC, after considering recommendations from EIA, broadcasters, and other interested parties, set a performance standard and the first color TVs with built-in caption display capability appeared on the market.

Captions are regularly transmitted along with most news and prime-time entertainment programming to make TV more accessible to the hearing impaired. They are sent in an otherwise unused portion of the TV signal and appear on the screen as text, much like the printed translations often placed on the bottom of the picture of foreign language films.

Until this point, viewing captions required the purchase of a special separate decoder. Since they included tuners and other circuitry that essentially duplicated the functions of the TV set itself, such decoders were quite costly. A significantly lower-cost decoder box is being introduced in 1992. This box has no tuner, but can decode accompanying program material for TV display captions from such sources as a cable tuner or VCR.

TV captioning decoder law is likely to have an impact that extends well beyond its basic aim of opening programming to a wider audience. Over time, as the number of TV homes with decoder-equipped sets expands, captions could become an important tool for helping children learn to read, or the foreign-born to become literate in English. Captions may also offer a new way for broadcasters to deliver emergency announcements or other important messages to viewers, or to provide English translations of foreign-language programming.

Home Satellite Earth Stations

Today, television programs are literally being plucked from the stars by viewers using a TVRO (TV Receive-Only) satellite earth station. Such stations make direct reception possible for programs which were intended primarily for the use of TV stations and cable TV systems. TVRO systems remain relatively expensive, and a complete installation can run into thousands of dollars. Even so, an estimated 3 million are now in use, and they are particularly popular in remote rural areas where there is limited access to cable and broadcast TV signals. Owners in more urban and suburban areas use TVROs to increase the diversity of programming available to them.

In 1984, Congress passed legislation clarifying the right of individuals to own TVROs and to receive and watch signals being transmitted by satellite. To protect their signals from unauthorized reception, the suppliers of the most popular satellite-fed programming began scrambling their programming. In order to watch such programming, TVRO owners must have a scrambling decoder or decoder-equipped receiver, and sign up for a subscription service. Subscriptions are available for individual program channels or whole program packages. The monthly fees are generally comparable to those paid by cable subscribers for similar services.

The growth of the home satellite receiver population has sparked the start of programming aimed exclusively at TVRO owners. Specialty subscription services primary attractions are first-run feature films and special pay-per-view sports and entertainment events. The first of such special services began transmitting in Ku-band channels in 1991. These services have higher powered signals than those found in the C-band, where most program channels are now situated. In most locations, Ku-band signals can be received using dish or flat antennas only 2- or 3-feet across, so they can easily be mounted in windows or on roof tops. Proponents of Ku-band expect the combination of small antennas and special programming will lead to a vast expansion in the demand for home satellite equipment. They suggest that in coming years manufacturers will be offering TV sets equipped with satellite, as well as broadcast and cable tuners.

Interactive Video Systems

Consumers have been directly interacting with their TVs for years using video games and other devices. Plans are underway to expand that through two-way cable and over-the-air systems which deliver a vast variety of activity options through the TV set. These include highly-detailed TV program listings with automatic set-up of VCRs for recording; home shopping and banking; event tickets; restaurant and travel reservations; access to various information sources, data banks, and video games; as well as special interest and pay-per-view programming.

While the cable industry has experimented unsuccessfully with such services for some time, recent technological advances have resulted in easy-to-use menu driven systems that are expected to have greater consumer appeal. In addition, the FCC has reserved spectrum space for two-way over-the-air interactive video, and the first such services could be operating in 1993.

AUDIO EQUIPMENT

More than 70 years after the advent of radio broadcasting and the first sales of radios, audio not only continues as a strong product category in its own right, but also as a central influence on the industry it founded—on home video and television and even within some sectors of the home information business. Some related product categories that draw on the strengths of current and emerging audio technologies are stereo TVs, stereo VCRs, home theater and even interactive multimedia. The bond between home audio and home video is exemplified by such products as combination laserdisc/compact disc players, and VCRs with advanced high fidelity audio recording capabilities. In the future, high definition television broadcasting, with compact disc-quality audio, and digital radio transmissions, will further cement audio's role as a driving force in the continued growth of consumer

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Factory Sales[1] of Audio Systems (Thousands of Units and Dollars); United States, 1982-1991 TABLE 1-15

YEAR	COMPACT SYSTEMS		COMPONENT SYSTEMS		TOTAL	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	2,218	428,157	319	144,659	2,537	572,816
1983	2,623	452,200	403	178,281	3,026	630,481
1984	1,678	245,989	1,540	729,760	3,218	975,749
1985	2,532	324,965	2,335	1,046,607	4,867	1,371,572
1986	2,690	319,979	2,158	1,050,295	4,848	1,370,274
1987	2,315	326,467	1,469	721,683	3,784	1,048,150
1988	3,049	336,383	1,666	888,653	4,715	1,225,036
1989	2,878	470,304	1,438	747,080	4,316	1,217,384
1990	2,447	465,836	1,557	804,159	4,004	1,269,995
1991	3,139	597,143	1,415	667,220	4,554	1,264,363

[1]Includes factory sales to distributors and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department.

electronics. The entire audio category is expected to increase 1.5% in 1992, reaching U.S. factory sales of $9.4 billion.

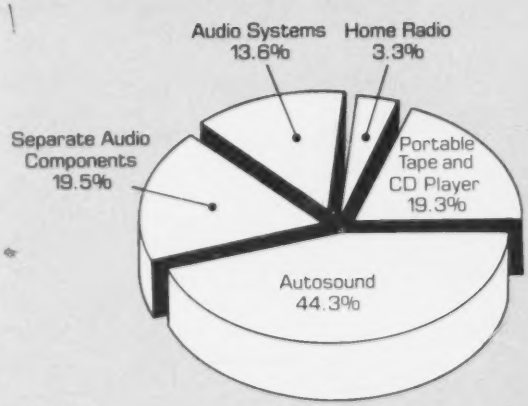
As in past years, home audio sales are fueled by America's affinity for the compact disc, the digital audio format introduced in 1983. CD players are now found in just about every possible configuration: as part of a home hi-fi system, built into car stereos, in the form of personal stereos and even in so-called 'boomboxes.' Not only have CD player sales grown each year, but the format has fostered a strong upgrade market for amplifiers and receivers, loudspeakers and even high quality tape decks.

If manufacturers' plans hold to form, in late 1992 the compact disc and digital audio tape will be joined by two new digital audio recording and playback formats, the Digital Compact Cassette (DCC) and the Mini-Disc (MD). The first consumer digital audio system, DAT, was battered by opposition from the worldwide music recording industry. A landmark agreement between the U.S. consumer electronics and music recording industries, which was reached in 1991, resulted in pending legislation before Congress and promises a better future for digital recording technology, including DCC and MD. The development of digital audio hardware parallels progress in digital audio transmission technologies via cable TV, terrestrial broadcast, and satellite transmission. Some cable TV systems already deliver compact disc-quality digital audio programming to their subscribers, and the Federal Communications Commission (FCC) is considering several proposals for digital audio radio broadcasts and direct satellite transmissions. It also seems certain that when the FCC chooses a standard for HDTV transmissions, that standard will also include provisions for digital audio. The Electronic Industries Association (EIA) is participating in the development of HDTV for the U.S., and in 1991 the EIA formed a technical subcommittee to help foster a single standard for digital audio radio.

However, the increased popularity of digital audio products has come at the expense of analog playback devices, namely the turntable and phonographic cartridge business, which continue to decline in the face of CD player sales. Dolby Surround technology is now available to consumers in surround sound processors and the newer THX controllers. Many of today's home audio receivers incorporate some form of surround sound decoding, and an increasing number of manufacturers are making electronics and loudspeakers designed specifically for use in home theater systems.

A growing part of the audio for video business involves custom installation, in the form of in-wall loudspeakers and electronics built into custom cabinetry. In addition, the custom installation market for audio has also expanded over the past four years, with the advent of a diverse selection of in-

Distribution of Factory Sales of Audio Equipment by Type (%); United States, 1991 FIGURE 1-F



Total = $9,267 Million

SOURCE: Table 1-1.

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wall loudspeakers, switchers, and other components used to build comprehensive home entertainment systems.

One-brand systems have endured a bumpy existence during the last six years. This category, comprising hi-fi component systems packaged by a single manufacturer, recorded a sales increase of more than five fold between 1983 and 1986, then fell dramatically the next year and has bumped along at an uneven pace ever since. However, this trend has been somewhat offset by a healthy gain in compact system sales, which expanded by more than 28% in 1991. Part of that gain is attributed to an increase in high performance compact systems, particularly those incorporating compact disc players.

Compact disc players for the car, both in-dash models and trunk-mounted changers, have also fueled a strong autosound aftermarket business. Autosound sales should expand in 1992 and 1993 on the strength of Digital Compact Cassette decks designed for cars, as well as the increased availability of more affordable digital signal processing components.

In a little more than 30 years, the audio components market has evolved from a small hobbyist segment dominated by vacuum tube and do-it-yourself kits, to a nearly $2 billion microprocessor-based industry that includes CD players, analog tape decks, receivers, separate tuners and power amplifiers, loudspeakers, turntables, digital audio tape decks, and soon several new digital audio formats.

By any measure, the audio category has experienced constant change over the years. Compact disc players have replaced analog turntables; analog cassette decks have overtaken reel-to-reel and eight-track hardware. Emerging digital audio recording formats promise yet another changing of the guard in the next few years.

An old audio industry axiom suggests that the two most important aspects of any audio system are the source component—a compact disc player, for example—and the reproducing component, or loudspeaker. If the source is lacking in fidelity, reproduction quality suffers. And if the loudspeakers lack performance, even the purist sources will not be heard.

The loudspeaker business remains one of the most competitive aspects of audio, both for the home and car. In addition to the major audio manufacturers, most of which make their own loudspeakers, dozens of small independent loudspeaker manufacturers in the U.S., Europe, and the Far East, compete for a share of the market with a dizzying array of designs and technologies.

The most common design employs a cone (made of paper or some other material) connected to a voice coil, which is suspended in a magnetic assembly. Electronic signals from the amplifier are applied to the voice coil which causes the cone to move. These movements displace air, creating sound waves which can be heard by the human ear. Most mid-range and bass loudspeaker "drivers" are based on some variation of this design. Tweeters, employed to reproduce the high-frequency sounds, are often made of exotic materials shaped in the form of domes or ribbons. In a loudspeaker system, the drivers are enclosed in a cabinet usually made from an acoustically-inert material such as dense fiberboard. Some manufacturers have even designed loudspeakers which use a single, full-range driver in the form of a flat membrane.

Loudspeakers are usually judged by two criteria: their ability to reproduce sound accurately with minimal coloration and distortion, and their ability to handle input power. However, a loudspeaker's particular sonic character, or "voicing," is as much an art as a science. Largely the trademark of a particular speaker engineer's talent, this along with construction quality is what determines a speaker's role—whether the speaker is an ultra-accurate studio monitor or a robust-sounding rack system partner designed for dancing.

Over the past few years, satellite loudspeaker systems, which include a subwoofer and two very small mid- and high-frequency drivers, have sparked more interest, particularly with consumers who have a limited space for their stereo systems. In-wall loudspeakers are also growing in popularity, because they use the wall itself as an enclosure. The development of in-wall speakers has spurred interest in the relatively new custom audio installation business.

Advent Of Digital Audio

The introduction of the compact disc, in 1983, has been universally hailed on at least two counts: it ushered in the age of digital audio, and it rescued the home audio business from a period of stagnation. In the last few years, the development of additional digital audio playback and recording devices, amplifiers and other components designed to process information digitally rather than in analog, and even the advent of loudspeakers with digital inputs, has virtually re-invented the home audio business and has had a profound affect on car, personal, and portable stereo.

Before CDs, virtually all consumer sound reproduction was analog. Turntable cartridge needles, traversing back and forth along grooves cut in a vinyl record, or tape deck playback heads, sensing the variations of electronic signals recorded on magnetic tape, recreated sound wave and frequency patterns. Although in theory, analog playback devices should be able to reproduce exactly what was recorded by sound engineers, physical limitations in analog equipment, such as imperfections on the surface of record albums and ambient hiss inherent in blank audio tape, often masked subtleties in the music and mar the listening experience.

Digital recording and playback devices eliminate these problems by "sampling" the music information at specific points on the sound wave recorded as binary numbers, in the same way that computers process information. This is why modified versions of DAT decks and compact disc players can be used as computer information storage devices. The "bits" of information stored on either magnetic tape or optical disc are converted into electronic signals and the signal processing section of the digital audio component interpolates the rest of the sound wave to recreate what was originally recorded.

The convenience factor is also behind the growing popularity of CD changers, players that hold up to five discs. They represent the fastest growing segment of the home CD business, along with combination CD/LaserDisc players.

A single 4-3/4-inch CD can hold more music—up to 75 minutes—than an analog LP. Most CD players can search and play back specific tracks in seconds. CDs require less care and cleaning than an analog record album. In the last couple of years, the music recording industry has begun to embrace the single-play CD, a 3-inch disc that can store up to 20 minutes of music.

Just as analog audio had turntables and tape decks, the digital audio market has been awaiting a digital tape format to accompany the compact disc. In the mid-1980s, manufacturers thought DAT was the answer, but stiff opposition from the music recording industry—which complained that DAT would cut into prerecorded music sales—effectively choked

Factory Sales[1] of Portable Audio Equipment[2] (Thousands of Units and Dollars); United States, 1982-1991 TABLE 1-16

YEAR	PLAYERS ONLY		RECORDERS/ PLAYERS		RADIO/TAPE/CD COMBINATIONS		TOTAL	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	3,643		6,409		10,611		20,663	970,954
1983	4,502	122,003	6,464	192,906	14,850	786,811	25,816	1,101,720
1984	5,614	128,670	5,349	170,081	17,298	891,821	28,261	1,190,572
1985	3,188	64,352	5,164	137,428	18,955	938,181	27,307	1,139,961
1986	3,517	62,116	5,447	143,027	27,318	1,184,034	36,282	1,389,177
1987	4,082	156,455	5,670	150,229	29,127	1,162,435	38,879	1,469,119
1988	3,973	171,974	6,156	166,572	26,306	1,208,204	36,435	1,546,750
1989	4,978	197,509	5,474	150,819	29,323	1,247,189	39,775	1,595,517
1990	4,656	232,512	5,341	142,345	29,157	1,269,977	39,154	1,644,834
1991	4,986	299,287	5,831	150,715	28,852	1,329,601	39,669	1,779,603

[1]Includes factory sales to distributors and factory direct sales to dealers.
[2]Excludes CD players prior to 1987.
SOURCE: EIA Marketing Services Department.

off the market for DAT. Although several manufacturers sell home DAT recorders and car DAT players, the product has not lived up to initial expectations.

However, in 1992, different manufacturers expect to introduce two new digital audio recording formats: Digital Compact Cassette (DCC) and Mini Disc (MD). In 1991 hardware manufacturers negotiated a compromise agreement, fearing that both could suffer the same fate as DAT without support from the music recording industry. The hardware manufacturers agreed to pay royalties on digital audio recording hardware and blank media and to incorporate a copy-limiting system which would only allow digital audio hardware owners to copy a digital copy of a compact disc or any other copyrighted digital audio source, while preventing anyone from making a digital copy of the copy. Both sides, the hardware manufacturers and the music recording industry, agreed to also support federal legislation mandating the provisions. In early 1992, The Audio Home Recording Act of 1991 was still under consideration in Congress.

The Digital Compact Cassette (DCC) is based on the Philips analog cassette format, the dominant analog consumer tape format. All DCC decks are designed to play back Philips analog cassettes, as well as recording and playing back DCCs. The format, which employs a form of data compression to record digitally, is supposed to offer near-compact disc quality, though most listeners will be hard pressed to tell the difference.

The same is true of Mini Disc (MD), an optical disc-based format which, in its first generation, has been designed as a portable audio system. Because MD recorders store a few seconds of audio in solid state memory, they are said to be virtually immune to the shakes and bumps that sometimes cause portable and car CD players to occasionally skip. Each 2.5-inch magneto-optical disc can store up to 74 minutes of digital audio information, which is recorded by an optical laser similar to that used in compact disc players.

Several manufacturers continue to explore the possibilities for a consumer CD player/recorder which will also be compatible with the current CD format. Several working prototypes have been demonstrated at consumer electronics trade shows, including the EIA sponsored Consumer Electronics Show (CES®).

Add-On Components

Even as the basic components in a home audio system improve from year to year, manufacturers have developed new products to further sculpt the electronic signal before it is converted into sound by a loudspeaker. Graphic equalizers, perhaps the most popular signal enhancers, allow consumers to reshape the tonal quality of music by emphasizing or diminishing different frequency ranges.

Over the last few years, more sophisticated digital sound processors (DSP) have become more prevalent. DSP units can acoustically reshape the music to create different listening environments. DSP electronically recreates the reflected wave patterns that form the acoustic characteristics of different venues, such that a living room can be acoustically transformed into an intimate jazz club or a booming cathedral, at the flick of a switch. DSP began as a home audio format, but several manufacturers have also begun to apply the technology to car audio systems. Some of these systems include a center front channel to help balance the sound for both the driver and the other passengers.

Since watching movies and other video programming is an auditory as well as a visual experience, better audio playback has become an important consideration in the design of many home video systems. Audio for video includes such products as magnetically shielded loudspeakers designed to be used close to a television set, audio receivers with multiple switching inputs for video sources, and surround sound decoders and THX controllers.

Surround sound has been a key component in the integration of audio and video. In addition to the front left and right channels, surround sound processors recover rear-channel information contained on many prerecorded video sound tracks

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and then relay it to two rear-channel surround sound speakers to create a swirling, almost three-dimensional sonic experience. Dolby Pro Logic® decoders, sold both as stand alone units and built into some audio/video receivers, also process a fourth, center channel that helps center dialog on the screen. THX, the home movie standard developed by LucasFilm, further refines sound track processing to improve imaging as well as the swirling 3D surround sound effects. As an example, consumers can hear an airplane fly past them as it travels across and eventually off the screen. Loudspeakers built to the THX standard are optimized for the sonic imaging requirements of a home theater.

A Dolby Pro Logic®, or THX surround sound system requires at least five loudspeakers: front left, right, and center, and two rear channel speakers. Home theater surround sound systems may also employ a sixth loudspeaker, a subwoofer, for low frequencies, to add the palpable 'feel' of thunderous explosions, engine roar, and other bass sounds associated with blockbuster movies. Surround sound decoders normally incorporate at least one amplifier to power the rear channel surround speakers. Some home theater systems employ a separate amplifier for each loudspeaker.

In addition to surround sound, some manufacturers have developed "three-dimensional" sound systems designed to locate different sounds at one specific point in space. They work by restoring, through complex signal processing, spatial cues contained in movie sound tracks. Some of these 3D sound systems have already been built into television sets.

Packaged Audio Systems

The all-in-one table model audio system, termed a 'compact,' has been a mainstay of the industry for two decades. Typically comprised of a turntable mounted in a cabinet with radio tuner/amplifier, plus cassette or cartridge tape facilities and/or compact disc, these units are relatively inexpensive, simple to install and operate, and easy to sell. However, alternate forms of audio systems have been gathering strength in the retail marketplace. Among the alternatives are complete audio systems produced by a single manufacturer and sold as a unit. These include a 'rack,' a wooden enclosure for the individual elements of the system. Often called 'one-brand' or 'uni-brand' systems, these ensembles are for those who want high-quality audio without having to match up components made by different companies, or without having to learn about performance specifications in order to make a buying decision. Such systems—like compacts—are also easy to install and operate.

Two other types of all-in-one uni-brand systems are becoming popular with consumers. One is the mini or micro component system, made up of units no more than half the size of traditional audio components. Although they are small, such systems provide the full complement of features common to traditional size components. The basic difference is that the amplifier power outputs are smaller than those of regular size amplifiers. The micro/mini systems are especially appealing to those with limited space for equipment, and those who want audio equipment to be minimally visible as home decor.

The other all-in-one system format is the so-called 'midi' system, made up of components sized between traditional models and micro/mini systems. These 'happy medium' systems satisfy those looking for smaller equipment, while having enough heft to satisfy the big-is-better syndrome. They also satisfy those seeking high amplifier power outputs.

Audio Tape Equipment

Over the years, the Philips format audio cassette and cassette recorder has survived tough competition to become the dominant audio analog format. Other formats include eight track, the El cassette, microcassettes, and reel-to-reel.

The success of the Philips cassette is able to be seen in the multitude of applications devised by manufacturers. Even as digital audio tape systems continue to move forward in development, audio manufacturers continue to incorporate the

Factory Sales[1] of Radios by Type (Thousands of Dollars); United States, 1982-1991 — TABLE 1-17

YEAR	HOME RADIOS: TABLE	HOME RADIOS: CLOCK	HOME RADIOS: PORTABLE	TOTAL HOME	AUTO	TOTAL RADIO
1982	22,396	178,211	329,076	529,683	1,048,963	1,578,646
1983	23,425	230,455	311,472	565,352	1,147,937	1,713,289
1984	22,989	299,220	339,107	661,316	1,902,336	2,563,652
1985	14,333	204,346	160,606	379,285	1,566,456	1,945,741
1986	6,608	197,609	203,287	407,504	1,683,033	2,090,537
1987	3,253	219,301	186,784	409,338	na	na
1988	5,755	199,217	172,201	377,173	na	na
1989	14,951	217,118	146,620	378,689	na	na
1990	10,907	196,409	152,383	359,699	na	na
1991	7,528	174,608	128,188	310,324	na	na

na-Not available.
[1]Includes factory sales to distributors and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department, Ward's Automotive Reports.

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Philips analog cassette in home recorders, car playback units, personal stereos, and boomboxes.

In the home, so-called dual-well recorders that incorporate two tape drives for dubbing from tape-to-tape have far surpassed single-transport decks, and now outsell them by as much as three to one. Many of the latest cassette decks also incorporate microprocessor controls to make recording and playback even more exact.

Cassette decks have also benefitted from advances in blank tape design and noise reduction circuitry, to the point where the best analog cassette decks with high quality tapes can approach the performance of digital audio hardware. The latest blank audio tapes, for example, incorporate improved formulations, with more densely packed magnetic particles, and improved shells that result in cleaner, more precise sound recording.

Dolby® noise reduction, though, is generally credited with elevating the compact cassette into the realm of high fidelity audio. Dolby B and Dolby C noise reduction, and Dolby HX Pro, reduced the level of audible tape hiss and extended the headroom on the tape to prevent distortion caused by oversaturation from intense music passages. In the last year, Dolby S, incorporated by several tape hardware manufacturers, has extended the capabilities of the analog cassette to near-digital audio performance.

Although Dolby S may extend the lifespan of the analog cassette system into the next decade, the new circuitry is not expected to delay the advent of digital audio tape hardware. Rather, it is a recognition that the Philips analog cassette is so entrenched in the U.S. and other world markets that it is almost sure to remain a strong product for years to come.

Autosound

While car makers struggle to make their product quieter inside and out, car stereo manufacturers continue to explore new levels of enhanced sound production. The variety of equipment has captured the attention of young and old, novice and experts alike who compete at popular events around the country for national awards.

The cassette, which overtook eight-track in popularity in the late 1970s, is still the playback medium of choice among consumers. But car CD players are quickly catching up, both as in-dash CD/receiver configurations and as multi-disc changers mounted in the trunk with in-dash control panels. Trunk-mounted changers also address the growing need to protect autosound equipment from potential thieves. Security concerns have also led to the development of in-dash models which can be pulled out and locked away, or carried off when not needed. Some models even incorporate a security system whereby the unit can only be reactivated by punching in a special security code.

Car DAT players, which first appeared as a dealer-installed option on some American luxury sedans, have lagged behind CD players and analog tape decks. This is due in large part to the dearth of prerecorded DAT software.

FM radios remain the single most popular piece of car stereo equipment, and most cars sold today have at least an AM/FM stereo receiver, if not a combination unit with radio and either tape or CD player. Manufacturers are also working on ways to extend the range of FM reception, eliminating multipath distortion and other artifacts.

Taking their cue from manufacturers of home audio equipment, car audio hardware makers have designed digital signal processing systems (DSP) for use in mobile audio systems. DSP reshapes the music signals from many sources (radio, cassette tape, car CD player) to recreate the acoustic characteristics of various music venues, such as concert halls, theaters, discos and small jazz clubs. Some of these systems include a center front channel to help balance the stereo effect for both the driver and the other passengers. Today, top quality sound reproduction in sophisticated vehicles is almost standard.

Factory Sales[1] of Radios by Type (Thousands of Units); United States, 1982-1991

TABLE 1-18

YEAR	HOME RADIOS			TOTAL HOME	AUTO	TOTAL RADIO
	TABLE	CLOCK	PORTABLE			
1982	808	8,210	23,645	32,663	12,306	44,969
1983	930	12,443	26,123	39,496	12,081	51,577
1984	1,354	16,316	28,783	46,453	15,630	62,083
1985	677	9,968	10,929	21,574	15,497	37,071
1986	337	11,330	13,696	25,363	15,783	41,146
1987	149	13,716	14,245	28,110	na	na
1988	170	12,425	11,028	23,623	na	na
1989	419	15,387	9,447	25,253	na	na
1990	357	11,497	9,731	21,585	na	na
1991	198	10,958	7,374	18,530	na	na

na-Not available.
[1]Includes factory sales to distributors and factory direct sales to dealers.
SOURCE: EIA Marketing Services Department, Ward's Automotive Reports.

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Imports of Audio Tape Equipment (Thousands of Units and Dollars[1]); United States, 1982-1991

TABLE 1-19

RECORDERS/PLAYERS

	AC ONLY		AC/DC		TOTAL	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	4,404	343,383	15,797	624,626	20,201	968,009
1983	6,687	387,585	14,502	592,504	21,189	980,089
1984	7,088	380,000	17,637	742,616	24,705	1,122,616
1985	5,268	317,150	18,355	759,821	23,623	1,076,971
1986	2,512	198,868	13,336	470,483	15,848	669,329
1987	2,716	199,839	17,418	515,074	20,134	714,913
1988	2,867	198,788	17,264	507,033	20,131	705,821
1989	2,135	206,594	21,530	736,617	23,665	943,211
1990	1,931	204,635	18,827	586,660r	20,758	773,295r
1991	1,904	207,356	23,025	729,716	24,929	937,072

PLAYERS ONLY (EXCEPT AUTO)

	AC ONLY		AC/DC		TOTAL	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	939	37,953	5,227	176,342	6,166	214,295
1983	897	20,679	7,263	175,209	7,960	195,888
1984	1,071	39,828	12,341	278,128	13,412	317,956
1985	1,418	55,290	12,653	304,385	14,071	359,675
1986	1,516	54,810	13,137	316,351	14,653	371,161
1987	1,522	57,026	22,137	424,963	23,659	481,989
1988	1,776	81,743	21,213	407,122	22,989	488,865
1989	2,578	58,483	32,198	1,181,531	34,776	1,240,014
1990	2,120	58,770	29,909	1,012,953	32,029	1,071,723
1991	2,571	82,489	31,729	982,122	34,300	1,044,611

	TOTAL HOME & PORTABLE TAPE EQUIPMENT		AUTOMOTIVE TAPE PLAYERS		TOTAL AUDIO TAPE EQUIPMENT	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	26,367	1,182,304	10,512	496,386	36,879	1,678,690
1983	29,149	1,175,977	13,423	640,729	42,572	1,816,706
1984	38,117	1,440,572	16,388	893,657	54,505	2,334,229
1985	37,694	1,436,846	18,483	1,083,562	56,177	2,520,208
1986	30,501	1,040,490	17,956	1,146,560	48,457	2,187,050
1987	43,793	1,196,902	17,407	1,207,103	61,200	2,404,005
1988	43,120	1,174,688	17,680	1,307,300	60,800	2,481,988
1989	58,441	2,183,225	16,519	1,341,175	74,960	3,524,400
1990	52,787	1,845,018r	15,375	1,094,154	68,162	2,939,172r
1991	59,229	1,981,683	13,501	1,000,054	72,730	2,981,737

r-Revised
[1]U.S. Customs value.
SOURCE: U.S. Department of Commerce.

Factory Sales[1] of Blank Audio Cassettes (Thousands of Units and Dollars); United States, 1982-1991

TABLE 1-20

	RETAIL DISTRIBUTION		INDUSTRIAL AND BULK DISTRIBUTION		TOTAL SALES	
YEAR	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
1982	155,637	202,417	30,810	17,021	186,447	219,438
1983	215,267	234,007	26,010	14,865	241,277	248,872
1984	228,119	256,468	26,678	18,219	254,797	274,687
1985	250,940	269,760	25,552	14,412	276,492	284,172
1986	303,895	300,257	19,785	12,450	323,680	312,707
1987	402,440	374,638	16,802	11,341	419,242	385,979
1988	378,463	366,853	16,043	11,884	394,506	378,737
1989	404,603	384,366	15,909	10,286	420,512	394,652
1990	427,516	376,150	13,283	9,037	440,799	385,187
1991	421,256	372,964	13,902	9,427	435,158	382,391

[1]Includes factory sales to distributors and factory direct sales to dealers. Excludes sales to duplicators. 1991 data includes endless cassettes.
SOURCE: EIA Marketing Services Department.

Portable Audio

During the 1970s, the portable radio began evolving into several new product categories, as a result of miniaturization and the evolution of the cassette into a truly hi-fi device. In the 1980s, two new product concepts showed significant growth: so-called 'convertibles' and personal portable music systems.

The convertibles are actually complete portable component stereo systems which can be used both in the home and on-the-go. Many boast swing-out or detachable speaker systems for enhanced stereo separation. All have stereo AM/FM receivers; most are equipped with stereo recorders; and some even include a small TV screen.

Personal, or headphone, stereo portables were originally introduced in 1979. Dozens of firms now manufacture and market cassette, radio, CD, and combination products. Their success is evidenced by the large number of users that can be seen virtually anywhere, listening while they walk, jog, bask in the sun, read, or ride public transportation.

Sales in 1991 were also strong for personal portable cassette models with record as well as playback capability. The market for these products is expected to remain strong, as more and more consumers recognize the advantages of enjoying entertainment on the move, without annoying others.

Radio

Stereo was added to FM radio in 1961, after the National Stereophonic Radio Committee, with EIA participation, examined several alternative systems. A single standard was specified by the Federal Communications Commission (FCC), and sales of stereo FM receivers grew rapidly as FM radio broadcasting spread across the country. FM has achieved an even greater penetration in the autosound market than it has in home and portable radios. More than 90 percent of new car radios last year contained an FM tuner section.

A different history describes the fate of AM stereo. The FCC authorized the start of AM stereo broadcasting in 1982, but then left the choice of a standard up to 'the marketplace.' Initially, six systems competed for the support of radio broadcasters and equipment manufacturers. Two have survived, but few audio manufacturers have thrown their support to either of the two, preferring instead to wait for a single survivor. Because AM radio signals have a much greater range than FM—hundreds of miles in some cases, compared to 50 to 75 miles for FM depending on the terrain—the addition of stereo would be particularly beneficial to autosound manufacturers. And yet, the development of a single AM stereo standard may prove to be a moot point; both radio broadcasters and audio equipment manufacturers have begun to focus on the next generation radio system, digital audio radio (DAR).

The FCC is considering several DAR proposals, including both terrestrial broadcast and satellite-delivered signals. The

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start of satellite-delivered digital radio services could result in the development of a national radio network, something many local broadcasters oppose. Although the National Association of Broadcasters (NAB) supports a system developed by a consortium of European companies, several new developers have come forward in the last year. It is unlikely that the FCC will choose a standard before the middle of the decade.

The EIA's subcommittee for digital audio radio has set several performance objectives for any system: compact disc-quality sound, immunity to multipath and other interference, no interference with other broadcast services, minimized transmission and reception costs; additional data capacity; and a minimum of objectional artifacts and degradation at the reception area threshold.

HOME INFORMATION EQUIPMENT

Driven by strong sales of personal computers, home office equipment continued its impressive growth, with 1991 U.S. factory sales topping $8.8 billion. This makes the industry a leading performer in consumer electronics. The strong showing indicates that home office equipment was virtually recession proof, with key product categories actually profiting from changing economic and work patterns.

Industry predictions for 1992 anticipate U.S. factory sales of more than $9 billion, representing a 50% increase in dollar volume since 1988. The availability of affordable technology has been a driving force in the home office market. Products such as personal computers, facsimile devices, and photocopiers—originally found only in large corporations—are now priced for the home office. Home versions of office products are designed for easy installation, yet are loaded with features that make them versatile, low maintenance, and productive office tools. According to BIS Strategic Decisions, a leading market research firm, the price of a fully-equipped home office has fallen an annualized 20%, from $6,250 in 1989, to $3,980 in 1991. Declining prices are only one part of the story. The home office category is profiting from significant economic and work trends that are sweeping the country. As companies downsize, the newly unemployed are starting their own businesses in record numbers. Those left on staff, under pressure to increase productivity and spend time with their families, are taking work home. In addition, to supplement their income, an increasing number of salaried employees are 'moonlighting' with home-based businesses.

According to the *Electronic Industries Association (EIA) Home Office Products Study, 1991* conducted by Market Facts, Inc., 36% of all U.S. households have a home office or dedicated work space. BIS Strategic Decisions projects the number of households with a home office to grow to 40 million by 1994. With an increasing number of Americans working at home either full- or part-time, there is an increasing demand for products ranging from computers and related software, facsimile devices, and feature phones.

As the work place expands to encompass the car, airplane, and hotel room, portable versions of home office products will continue to be a high-growth segment of consumer electronics. Cellular phones, laptop computers, portable faxes, and personal organizers are all becoming 'must-haves' for people on the go.

Another trend boosting home office equipment sales is the expanding number of retail outlets selling these products. Reaching beyond the corporate market to the more disbursed home office and mass market, manufacturers are offering products in retail outlets that formerly supplied only mainstream consumer electronics products such as TVs and stereos. Personal computers, fax machines, cellular phones, feature phones, and copiers are now sold in electronics superstores, mass merchandisers, warehouse clubs, and mail order catalogs.

The merging of the computer and consumer electronics industries is also spurring growth of the home office market. Manufacturers of both product categories are working in alliances that tap their unique technological, design, and marketing expertise. A byproduct of this synergy is evidenced in the current crop of very compact, user-friendly laptop computers. The future promises a range of sophisticated handheld computers in the form of easy-to-use consumer electronics products.

Computers and Computer Related

Home Computers

The personal computer celebrated its tenth birthday in 1991, with a 16.4% gain in unit sales, bringing sales volume to nearly $4.2 billion. Home computers accounted for 47% of factory sales dollars in the home office category and nearly 12% of consumer electronics sales.

Over 33% of U.S. households have at least one computer, about the same penetration rate as home CD players. The research firm Link Resources estimates that nearly a quarter of home office households own two or more personal computers. Home computer sales are expected to rise 10% in 1992, topping 7 million units.

Home computers have been available since 1975, with hobbyists as the main early customers. Sales grew slowly, finally reaching the 100,000 mark in 1978. In the mid 1980s, home computers profited from the popularity of video games, as computer owners recognized the improved speed and graphics capabilities offered by computers. Prices declined and sales soared, reaching 5.1 million units in 1984, when the public's appetite for the game-oriented products abated and manufacturers unloaded what were, in many cases, limited-function equipment.

Since the late 1980s, sales have grown steadily. A more mature market has emerged, as equipment companies, working closely with computer program developers, have focused on products that offer more practical applications. In 1990, 5.5 million computers were sold for home use, and sales reached 6.4 million in 1991, according to EIA estimates. Home computer sales have been a driving force behind the home office revolution, making it possible for millions of U.S. households to start home-based businesses which tap the computer's power to perform functions that once depended upon rooms filled with equipment or people.

New models reaching the mass market, led by powerful 386SX systems retailing for well under $2,000, feature larger internal memories and faster running times. Built-in hard disk drives, which make storing and accessing computer informa-

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tion more convenient and secure, have become standard even on budget-priced computers. With the price of 486 computers dropping sharply in 1991, sales of this segment of the microcomputer market grew 800-900% in 1991. 486 sales are expected to increase an additional 200-250% in 1992, according to the *Computer Industry Almanac* (Source: *Computer Reseller News*).

During 1991, computer marketers aggressively expanded their distribution to reach consumers where they are most likely to shop. Once cloistered in computer specialty shops, computers are now sold virtually everywhere consumer electronics are found—from mass merchandisers to electronics superstores to warehouse clubs.

Although mass-market retailers are gaining in importance, the computer specialist is the primary distribution channel, accounting for 34% of recent PC purchases, according to the *EIA Home Office Products Study, 1991*. Mail order is the second largest channel, with 10% of the market, followed by electronics specialty stores at 6%. Mass merchandisers, department stores, and warehouse clubs accounted for a combined 11% of PC purchases.

More user-friendly and portable systems are the focus of current research and development. The consumer market for pen-based computers, which can be used like clipboards and do not require keyboards, is expected to open up in the mid-1990s. Companies are also heralding the arrival of new hand-held computers, sometimes called 'personal digital assistants.' Envisioned as hand-held wireless communicators, electronic books, organizers, and multimedia players, these products are likely to overlap with current categories, such as electronic reference devices and personal organizers.

Computer Software

A computer is basically a collection of electronics—including microprocessors, boards, chips, and wiring—which are commonly referred to as computer hardware. In order for the computer to operate and perform specific tasks, the hardware requires instructions and programming, typically called computer software. Since there are several computer operating systems, also known as platforms, software designed for a specific platform usually is not compatible with programs for other systems' platforms. The two leading platforms are compatible with IBM and Macintosh systems.

Computers use two basic types of software. Operating system software supplies the basic instructions to the computer. Applications software allows the computer to perform specific tasks, such as word processing, accounting, maintaining lists, and playing games. The applications marketplace offers thousands of programs, ranging in price from under $50 to hundreds of dollars, and designed to be highly user-friendly.

Multimedia

Multimedia refers to the integration and display of text, video, graphics, and audio. Multimedia systems are also interactive, encouraging the user to be actively involved. However, the ultimate setup and application of multimedia is under debate.

Most computer manufacturers state that multimedia is an enhanced capability for the PC, which makes the computer monitor the critical tool. In contrast, the consumer electronics world tends to view multimedia as a new home entertainment box which is connected to the TV set. CD-I is an example of the latter approach. Experts drawn from both industries believe that multimedia will be a multi-billion dollar business. Yet, it is unclear at this point if the two approaches will co-exist, overlap, or compete.

The first so-called multimedia computers were introduced during 1991. Based upon 386 computer technology, these fully-featured models supplement hard disk drives with the expanded capacity of internal CD-ROM (compact disc read-only memory) drives. Computer owners with 286 or faster processors can also upgrade to multimedia by adding a CD-ROM drive, as well as extra memory and storage which may be required.

CD-ROM discs, while resembling CD audio discs, store huge amounts of audio, text, and graphics. A disc can hold as much as 300,000 pages of information. Several groups of manufacturers are backing different approaches to computer-based multimedia, each with their own proprietary CD-ROM discs.

The first CD-ROM software developed for multimedia computers included reference libraries—encyclopedias, dictionaries—and children's titles. Texts are brought to life with photos, drawings, animation, and sound. A growing multimedia market will increase sales of CD-ROM drives, memory boards, hard-disk drives as well as CD-ROM software. Since multimedia customers will want to see and hear their new software as clearly as possible, sales of high-quality color monitors and self-powered speakers are also expected to climb.

Computer Peripherals

Peripherals are computer add-ons which enhance the productivity, practicality, and professional quality of home computers. Essential peripherals for many home workers include printers, modems, monitors, extra disk drives, and facsimile boards. With new low-cost laser printers, which can be found in 9% of PC-households according to the *EIA Home Office Products Study, 1991*, a home worker can quickly generate a document that is indistinguishable from the standard in corporate America.

Since computer information can be transmitted over telephone lines with devices called modems, home workers can communicate via computers with co-workers at the office or clients across the country. With modems, a home office worker can also access distant information services and databases providing everything from the latest financial results to in-depth company reports. Home computers equipped with fax boards can transmit information directly over phone lines to any fax machine in the world.

Personal Word Processors and Electronic Typewriters

Sales of personal word processors (PWPs) and electronic typewriters decreased slightly to 3 million units in 1991, from 3.2 million in 1990. Estimates for 1992 indicate that the category will remain at the 3-million-unit level.

Designed specifically for home use, as opposed to office use, PWPs are the most advanced electronic typewriters. These products offer more features than conventional typewriters, but are easier to use than computers and are also less expensive. Even the most fully-featured systems retail for under $1,000. Recent models include fax/modems, higher quality displays, laser-quality printing, and storage on flexible diskettes. Another improvement has been file compatibility

with many PCs. Such enhancements indicate that PWPs will continue to exist whether on their own or comfortably next to computers in the home office.

Facsimile Devices

Declining prices have been the key factor in the rapid growth of the facsimile device, or fax machine, in the home market. To many home workers, the fax machine has become a crucial communications link with clients and customers. Unit sales of facsimile devices in 1991 posted a healthy 14.3% gain, with a 12% reduction in the average price per unit, down to $550. For 1992, another double-digit volume gain is expected, this time with nearly a 19% increase in unit sales. To appeal to the home office market, not only are prices shrinking, but so are the fax machines themselves. Recent introductions include models that cover a space no bigger than an 8 1/2" by 11" piece of paper. At the same time, features are expanding, with models offering such automatic conveniences as paper cutting, speed dialing, fax/phone changeover, and document feeding. In addition, fax machines using plain paper, rather than thermal paper, are becoming more popular as prices decline.

The fax category is positioned for a sales surge, with an overall U.S. household penetration rate of only 1%—and 6% penetration among income-generating home offices. BIS Strategic Decisions predicts the number of home offices with fax machines is likely to double during 1992.

Personal Copiers

Annual personal copier sales are expected to remain in the 325,000 to 365,000 unit range for the next few years. The *EIA Home Office Products Study, 1991*, pegged personal copier penetration in U.S. households at only 3% in early 1991. The typical copier currently retails for between $500 and $700. Recently, sales of copiers have been adversely affected by the success of other home office equipment. For example, in many home offices, fax machines double as copiers. PC owners equipped with laser printers can easily produce multiple copies of documents. According to industry experts, the key to sales growth is pricing. They expect unit sales to accelerate when $300 copier models arrive.

Telecommunications

Telephones

In 1991, factory unit sales of corded and cordless telephones climbed 10%, to almost 36 million. The sales surge in cordless units, which experienced a phenomenal 40.8% increase, indicates that consumers are enthusiastically embracing new telecommunications technology. Sales of 14.5 million cordless units, which topped the billion-dollar mark in factory sales for the first time, more than compensated for a slight decline in corded models.

During 1992, industry analysts expect the cordless market to increase 10% as new technology hits the market. By mid 1992, consumers will be able to purchase 900 Mhz frequency cordless models that offer better clarity, increased security, and extended range.

During the 1980s, telephone sales were driven by the popularity of electronic models offering the convenience of touch-button dialing and automatic redial. In 1992, consumers are able to find advanced features in models selling for as low as $25, as well as some cordless phones priced as low as $50. Telephones have become a fashion and personality statement, ranging from high-tech minimalist designs to football and Mickey Mouse phones. For the more practical-minded home office owner, multi-line phones with speed dial for more than 20 numbers, speakers, built-in answering devices, and three-way conferencing provide features once available only in costly business systems. Fully-featured home office models are commonly available at retail in the $75 to $200 range.

Telephone Answering Devices (TADs)

U.S. consumer's attachment to the their telephones extends to another category, telephone answering devices (TADs), which continued to expand, with sales of 14.5 million units in 1991. These automatic message takers ensure that important calls are not missed, which is especially crucial in the home office. With the expansion of corporate telephone mail and improvements in home TADs, callers usually cannot differentiate between reaching a major corporation and a small home office. The product's clearly perceived benefits are reflected in the number of telephones and fax models that now incorporate a message-taking feature.

The most important recent development in TADs has been the arrival of all-digital models. TADs are now more reliable and compact, based on a new technology that replaces audiotape with silicon chips for recording outgoing and incoming messages. Industry observers expect the digital TAD trend to attract many first-time customers, along with a large group of second-time buyers.

The top-of-the-line in current home telephone technology is the videophone, which includes a built-in TV camera and display screen. Using standard telephone lines, with a videophone hooked up on either end, callers can both see and hear each other. A $1,500 color videophone debuted at the Winter 1992 International Consumer Electronic Show® (CES®). Mass-market acceptance of videophones is only likely to occur with price reductions and picture-quality improvements.

Cellular Telephones

Once the status symbol of business tycoons and Hollywood moguls, the cellular phone is rapidly establishing a presence in the general consumer market. To many mobile executives and workers, the cellular phone has become a crucial wireless link to their offices and clients. As a result, annual unit sales have more than tripled since 1989.

Cellular telephones were introduced with the 1984 launch of cellular radio service. Areas in which the service is offered are divided into sectors, or cells, each with a receiving station that feeds calls into the telephone network. When a car equipped with a cellular phone passes into another sector, the call is automatically switched to the nearest receiving station. In addition to cellular phones designed for installation in cars, portable models are available which can easily fit in a briefcase, or even a shirt pocket.

Over 3 million cellular phones of all types were sold during 1991, representing a whopping 48% increase over 1990. Sales in 1992 should climb nearly 13%. Two factors contributing to

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the 1991 sales surge were the introduction of cellular service in many rural areas, and a 43% drop in wholesale prices, to $345.

During 1992, the first dual-mode analog/digital units will appear at retail, as carriers begin converting to digital cellular service this year. The new digital system will offer improved sound quality and better security, while also enabling three times as many callers to simultaneously access a cellular system. With household penetration at only 3%, and new technology on the horizon, cellular phones have strong sales potential in the years to come. Industry experts expect cellular phone sales to really take off once high monthly service and per-call charges fall.

Calculators and Reference Tools

Celebrating its 20th birthday in 1991, the consumer calculator set the pattern that would be followed over the years by other new consumer electronics products: more features for less money with each new generation. Early calculators were too big to fit in pockets and too expensive for the average consumer. With heavy power demands, the units required constant battery changes and performed limited mathematical functions. But, over the years, calculators continued to shrink in terms of size and price, while adding new features once available only on business equipment. Today, many people carry solar-powered calculators in their wallets, which perform complicated calculations and feature built-in memories. Retail prices for such models start at under $10.

The technology behind calculators led to the development of another category, electronic reference tools. These products, also credit-card size, range from dedicated spelling checkers and language translators, to encyclopedias and dictionaries. A new product that debuted in 1991, poised to expand the electronic reference category, is the "electronic book." In contrast to current reference cards, this hand-held product 'reads' the contents of tiny CD-ROM disks, containing up to 100,000 printed pages of information. Initial software includes encyclopedias, restaurant and medical guides, and the Bible—among other titles.

Electronic Organizers

Electronic organizers are poised to become an explosive category in the 1990s. Slightly more than 3% of U.S. households owned an electronic organizer in early 1991, according to the *EIA Home Office Products Study, 1991*. First introduced in the late 1980s as an outgrowth of calculator and time piece technology, electronic organizers today are more likely to resemble a tiny computer. As the public becomes more aware of their usefulness, electronic organizers are converting paper-bound consumers into hand-held electronics fanatics.

Early organizers were simple digital diaries and electronic phone books for storing appointments and phone numbers. Their memory was limited as was the range of functions they could perform. They were also stand-alone devices with no way to "talk to" other products. Now, a typical personal organizer keeps a schedule for years in advance, stores hundreds of addresses and phone numbers, performs advanced math, tells the time all over the world, and stores electronic memos. Retail prices range from just under $100 all the way up to $400, depending on memory and functions.

Some electronic organizers feature 128K of internal memory and built-in spread-sheet functions. With add-on cards and disks, organizers can increase their memory and even their functions. Accessory cards help users organize budgets, follow investments, and structure reports and memos. They can even transform the electronic workhorse calculator into an electronic game. In addition, organizers take an active part in today's communications network. Organizers can be linked to PCs for sharing and backing up data, connected to printers for producing hard-copy, and hooked up to modems for transmitting data over phone. Some models can also be equipped to send information directly to fax machines.

Product experts estimate that the electronic organizer category will grow 40% in 1992, with unit sales reaching 1.2 million, topping the one-million mark for the first time. Personal organizers are expected to show the same "upfeaturing"—more features for the money—trend that cuts across virtually all lines in consumer electronics. In the future, it is likely that the electronic organizer category will expand to become part of a larger product segment, joining other new products generated by the computer industry.

ACCESSORIES

Growth in the various consumer electronics product categories, and the current economic situation, have resulted in a major recognition and expansion of the accessories market. More and more attention is being given to the strength of this category which integrates with all other areas including video, audio, home computer, telephones, compact discs, headphones, musical instruments, and games. Accessories are those devices which are designed to adapt, modify, install, amplify, connect, clean, care for, maintain, and store consumer electronic products.

Video

The accessories designed to expand the performance of home video equipment, or to make it easier and more convenient to use, include a vast array of cables, carts, special effects generators, splitters, switches, videocassette storage systems, tape rewinders, VCR head cleaners, and various wireless items.

One of the most popular accessories is the universal remote control, which comes either pre-programmed or with the ability to learn from an existing remote the instructions needed to operate frequently-used functions, thus supplanting the separate remote devices previously required for a TV, VCR, cable box, or laserdisc player. Some can also operate remote audio equipment.

Another increasingly popular accessory, low-power wireless video transmitter systems are new to the market. A transmitter connected to a VCR or laserdisc player can send video and audio output to a receiver connected to a TV anywhere in the home, and without wires. Additional receivers can be hooked up so that all the TVs in the home can watch the wireless signal at the same time. Some come with infrared remote control extenders that enable the user to put the source video product (VCR, laserdisc player, or cable box) through its paces from the viewing location. Also relatively

Factory Sales[1] of Electronic Accessories (Millions of Dollars); United States 1987-1991 TABLE 1-21

	VIDEO ACCESSORIES	AUDIO ACCESSORIES	TELEPHONE ACCESSORIES
1987	290	360	85
1988	304	375	88
1989	258	392	84
1990	332	275	84
1991	276	239	85

	VIDEO CAMERA/ CAMCORDER ACCESSORIES	COMPUTER/ GAME ACCESSORIES	BATTERIES
1987	na	13	na
1988	61	19	1,570r
1989	60	35	1,375r
1990	70	32	1,529r
1991	99	22	1,570

[1]Includes factory sales to distributors and factory direct sales to dealers.
rRevised
na-Not Available
SOURCE: EIA Marketing Services Department.

new are VCR programming adaptors, at least some of which uses four- to eight-digit codes to instruct the VCR to record a desired program. The codes are available to consumers from regional TV show listings in many newspapers and magazines. Some of the latest remote controls accomplish the same task, but require the user to enter time, date, and channel information.

A rapidly growing number of camcorder owners are discovering the wide variety of accessories tailored specifically to their needs. These accessories include telephoto and wide-angle lens adapters, lens cleaners, tripods, battery-powered lights, extra batteries, and carrying cases. Interchangeable lenses are designed for some models, bringing camcorders closer to the true photography market.

Audio

Sound reproduction has evolved over the years, and so too have the accessories that provide extra convenience, and extend the lifespan of audio systems. No matter how sophisticated the hardware and software, consumers still have to find furniture to hold it, cleaners to maintain it, and add-ons to make everything easier to use. Although compact discs are generally thought to be virtually indestructible, smudges and dirt on the surface of the disc sometimes cause glitches. Therefore, manufacturers have developed various cleaners and cleaning solutions for CDs, as they have in the past for records and cassettes.

Other convenience products include universal remote controls which are able to replace the separate remotes from different audio components, timers to turn components on and off at predetermined times, speaker stands to raise loudspeakers off the floor for better sound, racks and other furniture to hold components, and storage devices for records, CDs, and cassettes.

Headphones remain a standard part of many home audio systems, and consumers now a choice of several different configurations and styles. Open air headphones, using a soft foam cushion on each ear, have grown in popularity in recent years, due in large part to their use in personal stereo systems. Yet, the traditional cup variety, which surrounds the ear in a soft shell remains the choice of many consumers.

Home Information Equipment

To help home office workers maximize their productivity, manufacturers offer an ever-increasing array of home information equipment accessories including: diskette storage units, power strips, surge protectors, printer stands, and mouse pads. A recent trend has been in the area of comfort, health, and safety with suppliers broadening their selections in chairs and furniture, monitor arms, copy stands, wrist rests, and anti-glare screens.

HOME AUTOMATION

The 'electronic home of tomorrow,' long the province of futurists and science fiction writers, is becoming a reality in the 1990s. Although some home automation products have been available for years, their appeal has been limited by their cost or limited span of control. These limitations have led to the development of a number of open-ended home automation standards including one now being finalized by the Electronic Industries Association's (EIA) Consumer Electronics Group (CEG). Manufacturers will offer U.S. homeowners the first consumer electronics products and appliances capable of 'talking' to and controlling one another, rather than just relying on 'smart' switches and outlets such as those which are available today.

The proposed standard is designed to work via all existing household media, including the power line, twisted-pair (telephone) wiring, coaxial cable, radio frequency (RF) and infrared (IR) communications links, and, in the near future, fiberoptic cable. When given final approval by participating companies and published by EIA/CEG, this home automation standard, currently known as CEBus (Consumer Electronic Bus), will provide what has been described as 'a multi-lane highway' designed to permit home products and services to exchange control signals and other information. In early 1991, the world's first public demonstration of a CEBus-automated home opened in Indianapolis, Indiana.

With all products equipped with specially-designed computer chips, consumers will be able to perform a wide variety of home automation functions. For example, the homeowner can electronically check his or her security systems before retiring for the night, turn off the lights, adjust the thermostat to a comfortable temperature, and switch off the late movie or the news—all by simply touching the bedside controls, and without having to program a computer. From a remote location, the homeowner can regulate the temperature or turn on the lights by phoning the house and punching in the appropriate codes.

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The infrared and twisted pair sections of the EIA home automation standard were approved as interim standards in early 1991. The interim infrared standard covers the transmission of signals to integrated CEBus products. The interim twisted pair standard covers areas such as the interfacing of security devices with telephone equipment. Twisted pairs facilitate flexible room-to-room communication. Moreover, adoption of the full CEBus standard will almost certainly spawn a host of new, 'smart' products, all with common interfaces, which will take full advantage of their built-in microcircuitry.

HOME SECURITY SYSTEMS

Sixteen percent of all U.S. households currently have some type of electronic security system installed in their homes, according to manufacturers' estimates. This penetration rate has nearly doubled since 1987, as consumers have become more concerned with household protection and more aware of the security systems available. Included in this product area are fire protection and burglar detection systems. Although the systems' components vary, they generally have a command center and entry sensors. Additional components include indoor light flashers, glass break sensors, outside sirens, and signal relays for larger homes. A telephone dialer with central monitoring capabilities is also available. While professionally-installed systems have dominated the home-security market in the past, a new generation of 'do-it-yourself' (DIY) security products is being introduced. These products are easy to install and much lower in cost than professionally installed systems. DIY systems are selling for less than one-third of the price of ordinary systems. The basic DIY security system is retailing at less than $200, and deluxe systems are selling for around $500. In addition to the market for new installations of home security systems, a significant after-market exists among consumers who have already purchased security systems.

Vehicle Security

While original equipment manufacturer (OEM) installations of vehicle security equipment, which entered the market around 1977, have remained low, aftermarket sales of theft deterrent systems have steadily risen in recent years due to the unfortunate spread of motor vehicle theft.

Aftermarket sales opportunities remain strong in part because the variety of anti-theft systems offered in the market is an important element in theft deterrence. Uniformity of product translates into predictability of installation, leading to the possibility of penetration by professional thieves of entire lines of like vehicles equipped with the same system. Above all else, this will ensure ample sales opportunities for aftermarket vehicle security products. The emerging technology of vehicle location and recovery also holds promise of sales and service.

Consumers have many options regarding vehicle security, with more sophisticated products being offered each year. In addition to simple steering wheel locks, security systems may be installed to block ignition start-up and to detect the shattering of glass and shock to the vehicle. Some systems include convenience features capable of flashing the headlights, unlocking doors, opening windows, and releasing trunk locks. Many remote control systems also include personal protection or panic alarm features.

ASSISTIVE DEVICES

It is estimated that between 15% and 20% of the U.S. population experiences some form of functional limitation. Persons 65 years and older now number well over 30 million, and many of these U.S. senior citizens report reduced abilities brought on by the aging process. U.S. government statistics estimate that the total number of Americans with disabilities, including the elderly, totals 43 million.

The Assistive Devices Division (ADD) of the Electronic Industries Association (EIA), which was incorporated into the EIA Consumer Electronics Group (CEG) in 1989; represents manufacturers of assistive devices for people with functional limitations. It is the only organization of its kind to represent manufacturers of electronics of every type for every disability category, including impairment of vision, speech, hearing, motion, and more. The ADD consists of private companies of every size, from those with only a handful of employees to huge multi-tiered corporations.

Enactment of the ADA

For a person with a functional limitation, the proper electronic device often means the difference between working or not working. Products such as braille printers, voice-activated calculators, talking spellcheckers, telecommunication devices for the deaf (TDDs), and others produced by EIA ADD member companies enable individuals with disabilities to enter or rejoin the work force and become active, productive participants.

These products also enable employers to comply with the Americans with Disabilities Act (ADA), which goes into effect in 1992. The ADA mandates that "reasonable accommodation" be made for employees or potential employees with disabilities. Such accommodation may involve the purchase of assistive devices. Since passage of the ADA in mid-1990, EIA/CEG and its ADD members have worked consistently to promote awareness of the products that are available for individuals with disabilities.

Helping The Visually Impaired

Many of the products produced by ADD members are designed for communication purposes. For the blind or visually impaired, personal computers can be fitted with scanners to 'read' written materials, transform the words into braille, and print a hard copy in braille or send braille letters into an electronic display. There are also computer screens and software offering large print and high-contrast magnified pages, as well as computers that accept voice commands and allow users to do word processing, accounting, and even phone someone simply by speaking. Braille laptop computers and hand-held personal scanners are also now available.

Systems controlled by voice commands can also help the blind and visually impaired gain independence at home. Home automation has the benefit of enabling individuals with

disabilities to control their home environment through such methods as voice commands, timers or remote control of lights, TVs, electrical appliances, and security systems.

Tools For The Deaf

Telephone devices and listening aids have greatly improved communication capabilities for the deaf and hearing impaired. Telephone amplifiers enhance the clarity and understanding of speech over the phone and may be left in place on the telephone without affecting its normal use. Tone ringers enable the telephone to ring in a special frequency range that most hearing-impaired can hear. For the severely disabled there are devices which may be hooked up to lamps or overhead lighting, causing the lights to flash when the telephone is ringing.

Deaf individuals and those with profound hearing impairment are able to benefit from TDDs (telecommunication devices for the deaf), small printers which hook up to the regular telephone and electric outlets and allow their users to receive printed communications via the telephone. Add-on systems allow for automatic answering machine capability, call monitoring, and emergency dialing, and some even facilitate the connection to recorded services such as airline reservations, stock information, and electronic home shopping services.

Compact personal amplifiers enable the hearing impaired to hear a television, listen in a group, or communicate in a noisy or reverberant environment, without disturbing others. In an office environment, computers may be equipped to provide visual cues instead of system beeps, and at home, security systems may be programmed to flash the lights when the alarm trips.

Other Assistance

The disabled community is also comprised of speech-impaired, motor-impaired and cognitively disabled individuals, each with a special set of needs which are now being met by electronics manufacturers. For those unable to speak, there are various voice synthesizers and speech devices which facilitate easy communication. Large-button and specially keyed computers and telephones ease use for those with motor impairments, and 'sip and puff' and voice-activated devices allow for greater mobility of the severely physically handicapped. Speakerphones make telephone conversation possible for those unable to hold a handset, and cordless phones enable individuals confined to wheelchairs to have access to the telephone wherever they may be.

At home, the physically disabled are aided dramatically by home automation. A bed-ridden individual is able to control his or her entertainment products, drapery, lights, telephone, hot water heater, security system, and even answer the door without assistance.

For the cognitively disabled, there are numerous computer software programs which help overcome learning difficulties and allow formerly dysfunctional individuals to learn and to contribute productively to the workforce. Devices have also been designed to aid in the care of the cognitively disabled, such as electronic wristbands that alert the caretaker if the individual wanders off unattended.

General Health Care

Electronics and health now go hand-in-hand. Available for routine in-house use are instant electronic thermometers, easy-to-use blood pressure gauges and highly accurate scales with digital display. Specialized versions of other electronics products, such as calculators and watches, help count calories and check pulse rates. Computer programs for menu planning, and videocassettes with informational programs on exercise, diet, baby care, and general health tips are also on the market.

PERSONAL ELECTRONICS

Electronic products designed for use by a single individual are commonly referred to as 'personal electronics,' and sales in this category continue to flourish.

Electronic Watches

The old tick-tick of the mechanical watch has been superseded by the silent, split-second accuracy of the electronic timepiece. From plastic-encased digital throwaways costing just a few dollars, to high-precision chronographs housed in gold and accented with diamonds, electronic watches are bought by the millions each year.

Electronic and electro-mechanical watches have opened a whole new market, with styles in all shapes, sizes, and price ranges, offering a choice of digital display or what appears to be a traditional dial-and-hand face. They are worn as pendants, pins, on bolo ties, and on hair barrettes. They are popping up on the sides of novelty purses, backpacks, and briefcases. Some are combined with pens, and others come with stick-on backings for fastening to car dashboards, refrigerator doors, or next to telephones.

Specialty watches do more than tell time. Some models display the temperature or heartbeat rate of the wearer; others indicate the best days of the month for getting pregnant; function as calculators, stop watches or alarms; show world time; and even play video-like games. Others offer features to calculate distances walked or jogged, to time yacht races, or to calculate average speeds, time of arrival, and distance covered.

Toys And Games

The electronic toys and games market includes radio-controlled vehicles, video games, robotic toys, and non-video electronic games. The video game sector, which includes video game consoles, plug-in game cartridges, and game programs for personal computers, has become a billion dollar industry. Video games have grown in popularity to the point that one software company even offers an instructional video to help parents choose the 'right' video games for their children and to control gametime by integrating it into chores and schoolwork.

A new generation of video game consoles with greater sophistication, spectacular graphics, animation, and digitized sound effects led to substantial growth during the last half of the 1980s and into the 1990s. Several companies introduced handheld games consisting of approximately two-inch square

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Imports of Consumer Electronic Products (Thousands of Units and Dollars[1]); United States, 1982-1991

TABLE 1-22

YEAR	COLOR TELEVISION UNITS	COLOR TELEVISION DOLLARS	MONOCHROME TELEVISION UNITS	MONOCHROME TELEVISION DOLLARS
1982	2,228	545,584	5,521	343,648
1983	4,849	797,240	5,281	292,104
1984	6,441	1,089,266	6,462	360,347
1985	7,685	1,113,770	6,381	349,111
1986	9,755	1,525,192	6,556	325,323
1987	9,886	1,499,983	5,220	263,024
1988	8,289	1,366,958	3,050	158,097
1989	10,400	1,746,758	3,014	165,885
1990	9,332	1,659,132	2,211	123,446
1991	9,269	1,603,051	1,649	88,764

YEAR	HOME RADIOS UNITS	HOME RADIOS DOLLARS	AUTOMOBILE RADIOS UNITS	AUTOMOBILE RADIOS DOLLARS
1982	33,744	543,221	3,605	167,337
1983	38,637	567,429	4,507	257,495
1984	48,935	655,615	4,871	299,718
1985	43,501	609,763	5,035	311,357
1986	40,455	532,987	3,665	209,155
1987	39,238	583,577	2,999	168,696
1988	36,894	565,452	3,067	184,118
1989	40,256	637,845	2,596	198,542
1990	35,596r	701,476r	1,830	173,221
1991	37,101	735,576	2,159	220,062

YEAR	HOME AUDIO EQUIPMENT[2] UNITS	HOME AUDIO EQUIPMENT[2] DOLLARS	OTHER AUDIO/VIDEO EQUIPMENT UNITS	OTHER AUDIO/VIDEO EQUIPMENT DOLLARS
1982	28,489	1,342,499		
1983	31,685	1,337,067		
1984	40,703	1,629,302		
1985	40,981	1,822,553		
1986	33,548	1,807,066		
1987	47,435	2,343,086		
1988	48,012	2,784,988		
1989	50,191r	959,520r	170,386	956,715
1990	37,572r	958,674r	150,208	1,148,194
1991	29,174	1,023,640	114,592	1,297,647

YEAR	AUTO TAPE PLAYERS UNITS	AUTO TAPE PLAYERS DOLLARS	VIDEOCASSETTE RECORDERS/PLAYERS UNITS	VIDEOCASSETTE RECORDERS/PLAYERS DOLLARS
1982	10,512	496,386	2,462	1,031,966
1983	13,423	640,729	4,760	1,605,771
1984	16,388	893,657	9,377	2,852,737
1985	18,483	1,083,562	16,262	4,165,103
1986	17,956	1,146,560	17,605	4,403,711
1987	17,407	1,207,103	13,305	2,895,846
1988	17,680	1,307,300	11,696	2,506,246
1989	16,519	1,341,175	16,401r	4,347,293r
1990	15,375	1,094,154	15,856r	4,355,599r
1991	13,501	1,000,054	17,646	4,763,433

r-Revised
[1]U.S. Customs value.
[2]Does not include loudspeaker equipment prior to 1989.
SOURCE: U.S. Department of Commerce.

monochrome or color liquid crystal screens, with headphones for stereo sound effects. In the early 1990s, competition remains strong as companies advance with 16-bit games, which offer more of an arcade-like experience. This 16-bit technology has been a large factor in the continued growth and expansion in the toys and games category.

Manufacturers also appear to be broadening their customer base by offering new software and accessories targeted to adults. Recently, new interactive-TV products, wireless joysticks, and even video game 'gloves' have stimulated video game sales to adults by allowing the games to incorporate their own body movements into the action of the game. Adults are also investing in expensive game storage units and locks to prohibit children from using their equipment without supervision. And, in early 1991, new hand-held game cartridges were introduced that convert game machines into a hand-held reference device, spell checker, or translator.

Musical Instruments

Electronic keyboards automatically come to mind whenever mention is made of electronic musical instruments. The electronic keyboard celebrated its Golden Anniversary in 1989. During its first 50 years, it evolved from a basic keyboard into a complex instrument with the ability to synthesize the voices of all the instruments in a symphony. Advanced models on the market are able to memorize virtually any sound—including a dog's bark, car horn, or telephone ring—and reproduce it as part of a composition.

In addition to diversity of sounds, electronic keyboards also offer consumers the benefit of real value. With models ranging from as low as $50 to those costing several hundred dollars, the electronic keyboard has become a mass market item for everyone from beginners to expert composers. Their compact size assures portability and also makes it possible for individuals who do not have enough space in their home for a full-size piano or organ to enjoy creating music. And for parents, the electronic keyboard offers the option of a lower cost investment in their children's musical training.

Electronic musical instruments are by no means limited to keyboards. Electronic drums, guitars, horns, and other synthesizers are available. Growing in popularity is the use of Karaoke—sing-a-long equipment. Karaoke players come with microphones so singers can add their voices to the recorded music, and are most often used with special Karaoke music-only audio and video tapes and discs. Popular musical accessories include wireless microphones, voice synthesizers, and mixer microphones to add music to home videos. There are a number of computer software packages which enable a musician to connect an electronic instrument to a computer in order to compose music for an entire symphony. Other software allows its user to play a tune on an electronic instrument and have the computer translate the tune into sheet music.

Electronics For Children

A vital new market has opened in recent years for electronics geared toward the very young. With many children learning to use computers in their pre-school years, instructional pro-

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Exports of Consumer Electronic Products (Thousands of Units and Dollars[1]); United States, 1982-1991 TABLE 1-23

YEAR	COLOR TELEVISION UNITS	COLOR TELEVISION DOLLARS	MONOCHROME TELEVISION UNITS	MONOCHROME TELEVISION DOLLARS
1982	381	138,939	138	16,632
1983	237	83,804	52	6,770
1984	267	92,632	79	8,044
1985	267	85,806	101	11,561
1986	357	116,955	77	10,947
1987	490	155,795	96	12,335
1988	1,404	404,557	266	25,908
1989	2,549	377,223	765	52,826
1990	2,194	423,108	759	54,561
1991	2,509	491,843	749	57,257

YEAR	HOME RADIOS UNITS	HOME RADIOS DOLLARS	AUTOMOBILE RADIOS UNITS	AUTOMOBILE RADIOS DOLLARS
1982	413	11,675	758	71,552
1983	279	9,210	742	75,884
1984	484	10,898	816	96,055
1985	523	13,986	685	72,094
1986	760	17,825	802	78,414
1987	1,096	23,391	1,039	100,480
1988	1,978	51,506	2,196	179,436
1989	1,867	43,423	1,332	146,425
1990	2,945	55,217	1,837	253,105
1991	2,267	63,013	1,933	276,620

YEAR	HOME AUDIO EQUIPMENT[2] UNITS	HOME AUDIO EQUIPMENT[2] DOLLARS	OTHER AUDIO/VIDEO EQUIPMENT UNITS	OTHER AUDIO/VIDEO EQUIPMENT DOLLARS
1982	475	88,407		
1983	181	50,699		
1984	194	49,211		
1985	285	59,738		
1986	423	67,911		
1987	589	94,723		
1988	2,089	234,408		
1989	6,304r	191,740r	963	401,902
1990	7,756r	236,768r	1,266	501,324
1991	7,843	226,958	1,489	612,236

r-Revised
[1]U.S. Customs value.
[2]Does not include loudspeaker equipment prior to 1989.
SOURCE: U.S. Department of Commerce.

grams and computer games are now being offered for children as young as three years of age. Certain computer software even lets children create their own illustrated story books.

There are radios, cassette players and recorders, and CD players designed for the younger set, as well as several models with built-in microphones for sing-along fun or built-in synthesizers to produce percussion or animal sounds. Also available are easy-to-use musical instruments, electronic word games, math games, and watches to teach children how to tell time. For the very young, there are talking bears and animated dolls; and for children, there are electronic dictionaries, remote-controlled cars and robots, and more sophisticated electronics. Walkie-talkies and various electronic tub toys round out the children's electronics market. This area has grown into a major section of the consumer electronics industry, with products ranging in cost from around $30 to $200.

IMPORTS AND EXPORTS OF CONSUMER ELECTRONICS

Imports of consumer electronics were $14.9 billion in 1991, an increase of 1.3% from 1990. Videocassette recorders/players accounted for approximately 32% of import dollar volume. Total audio tape equipment accounted for the second largest category with imports of more than $2.9 billion, while color television imports totaled $1.6 billion. Total dollar values of other import categories can be found in Table 1-22.

Total 1991 exports of consumer electronics amounted to $2.7 billion, a 13% increase over 1990. Exports of color television accounted for nearly 18% of the dollar value of total exports. This represented growth of over 16% from exports of color television in 1990. Exports of automobile radios, also showed strong growth, rising 9% to $277 million. Total dollar values of other export categories can be found in Table 1-23.

The trade deficit for consumer electronics was just over $12.1 billion in 1991. This represented a decline of 1.1% from the $12.3 billion consumer electronics trade deficit in 1990. Imports, exports, and the balance of trade for consumer electronics products by country are detailed in Chapter 7, "Electronics and the World Economy."

CONSUMER PRICE INDEX

The Consumer Price Index dramatically emphasizes the remarkable "value" offered to the public by the products of the consumer electronics industry. As of December 1991, the index for all products listed in the Bureau of Labor Statistics

Annual Consumer Price Index by Product Type (1982-84 = 100);[1] United States 1984-1991 TABLE 1-24

YEAR	AUDIO PRODUCTS	TV	ALL ITEMS
1984	97.7	95.5	103.9
1985	94.4	88.7	107.6
1986	91.8	83.2	109.6
1987	93.0	79.7	113.6
1988	91.9	75.3	118.3
1989	94.3	75.8	124.0
1990	93.3	73.1	133.8
1991	95.0	72.3	137.9

[1]1982-84 base period used is the average over the 36 month timeframe.
SOURCE: U.S. Department of Labor.

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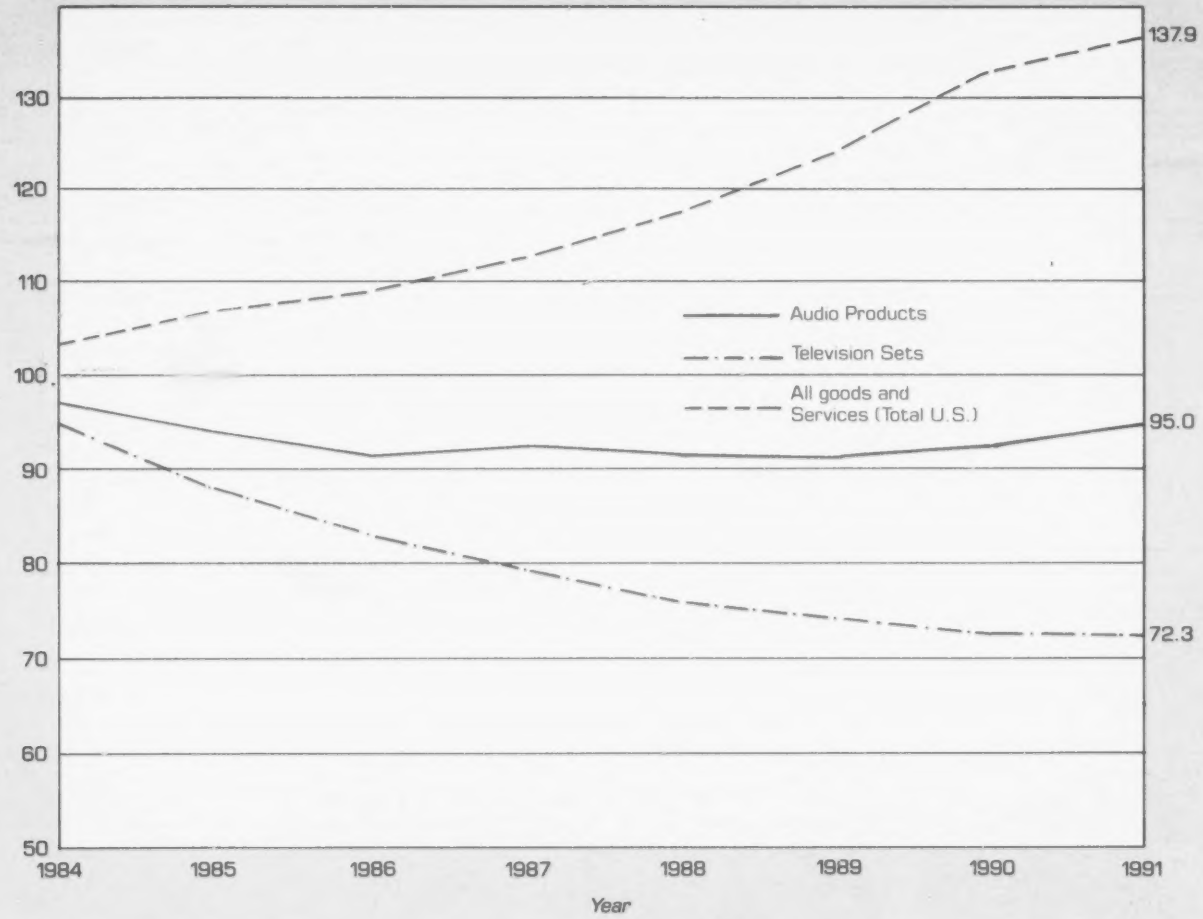
Annual Consumer Price Index by Product Type (1982-84 = 100), United States, 1984-1991 FIGURE1-G



Consumer Price Index had increased to 137.9 versus 100 for the CPI base period of 1982-1984. The Index for television, however, declined for the second consecutive year, reaching 72.3, while audio products increased slightly from 93.3 to 95.0.

MARKETING CONSUMER ELECTRONICS PRODUCTS

The vast array of consumer electronics products which line the shelves of the tens of thousands of U.S. retail outlets, are the combined result of a global workforce of business executives, scientists, engineers, production workers, marketing and advertising specialists, and sales personnel.

Entrepreneurs continue to invent new consumer electronics products in basement workshops and garage laboratories, but the reality of the international marketplace makes one-person breakthroughs increasingly rare. Today, global companies invest millions, even hundreds of millions of dollars, in research and development for new products and technologies. They then achieve economies of scale with which the small company is hard pressed to compete.

In addition to R&D and cost-of-production advantages, the manufacturer of consumer electronics products often allocates considerable resources for testing prototypes and market research. It is not unusual for a product to go through the design-prototype-field test cycle several times before a decision is made on whether it should be put into mass production and brought to market.

Just as the prospects of the industry are constantly changing, business practices, too, are continually updated to keep pace with new merchandising and distribution techniques. Distribution patterns vary widely among manufacturers. Whereas some manufacturers employ the 'two-step' method of distribution (under which distributors buy from the factory and sell to retailers), others have opted to abandon this approach in favor of moving merchandise directly into a wide

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Consensus of Estimates

TABLE 1-25

Data contained in the following tables reflect a consensus of estimates provided by EIA Consumer Electronic Group Marketing Service Committee members and independent research firms. These data are not derived from regular EIA Marketing Services Department reporting programs. In all cases, unit activity represents total annual U.S. sales to dealers in thousands of units. All dollar figures represents total annual U.S. factory sales in millions of dollars.

Home Computers and Security and Satellite Earth Station Systems

Year	HOME COMPUTERS		HOME SECURITY SYSTEMS		HOME SATELLITE EARTH STATIONS		PERSONAL WORD PROCESSORS/ TYPEWRITERS	
	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)
1982	2,000	1,300	na	na	na	na	na	na
1983	4,800	1,950	na	na	na	na	na	na
1984	5,100	2,250	na	na	na	na	na	na
1985	4,100	2,050	na	600	na	na	na	na
1986	3,800	2,890	na	720	235	256	2,700	580
1987	4,000	2,920	na	800	250	304	2,900	620
1988	4,500	3,150	na	900	275	331	3,100	650
1989	5,000	3,500	na	1,000	300	365	3,200	688
1990	5,500	3,795	na	1,150	330	421	3,200	656
1991	6,400	4,160	na	1,250	310	408	3,000	600

Telephones and Answering Devices

Year	CORDLESS TELEPHONES		CORDED TELEPHONES		CELLULAR TELEPHONES		ANSWERING DEVICES		FACSIMILE DEVICES	
	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)	Units (Thousands)	Dollars (Millions)
1982	2,000	200	3,700	200	na	na	850	110	na	na
1983	4,700	400	15,000	525	na	na	2,200	190	na	na
1984	6,300	460	24,000	790	25	50	3,000	230	na	na
1985	4,000	280	21,000	630	75	115	4,220	325	na	na
1986	4,100	295	18,100	561	280	266	6,450	464	na	na
1987	6,400	435	15,900	461	300	267	8,800	607	na	na
1988	8,200	681r	15,200	441	500	430	11,100	755	na	na
1989	10,000	830r	19,000	532	870	653	12,500	838	250	188
1990	10,300r	855r	22,400r	627r	2,100	1,260	13,800r	842r	350	219
1991	14,500	1,233	21,400	599	3,100	1,070	14,500	928	400	220

Estimated Household Penetration by Product (As of January 1992)

All Television	98%	Compact Audio Systems	63%
Color TV	97%	Rack Audio Systems	54%
Color TV With Stereo	31%	Home Radios	98%
LCD TV	7%	Home CD Players	35%
Monochrome TV	52%	Autosound CD Players	9%
Projection TV	8%	Cordless Telephones	41%
VCR Decks	77%	Telephone Answering Devices	46%
Camcorders	17%	Cellular Telephones	3%
TV/VCR Combinations	3%	Home Computers	33%
Laserdisc Players	1%	Home Fax Devices	1%
Home Satellite Earth Stations	3%	Home Security Systems	16%
Audio Systems	94%	Video Game Software	31%

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variety of retail outlets. Other manufacturers prefer a combination of the 'one-step' and 'two-step' methods of distribution.

Some marketers sell to dealers through independent 'manufacturers' representatives,' who typically handle a variety of related lines and perform some of the functions of a distributor without actually purchasing or warehousing the product. There is also a thriving 'private-label' business in the United States and around the world, whereby specially designed products are manufactured to carry the brand names of the retail store or other merchandisers.

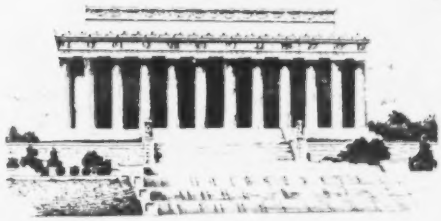
The emergence of literally dozens of new consumer electronics product categories has given rise to many new forms of retail establishments. Radios, television sets, and phonographs were once sold chiefly by radio/TV/appliance dealers, department stores, and music stores. The audio retail specialist appeared in the 1970s. During the 1980s, such innovations as VCRs, camcorders, and stereo TVs produced a trend toward video specialization. In much the same way, specialty stores have been established for the sale of personal computers, telephone equipment, car audio, and video software. Discount catalog showrooms and consumer electronics departments in traditional stores have also flourished in the estimated $47-billion U.S. retail market for audio, video, and home information products.

At one time, most major manufacturers made one principal model change a year. They would typically introduce their new models to the trade in the late spring or early summer, often at the EIA/CEG sponsored International Summer Consumer Electronics Show® (CES®) in Chicago in May or June. It was at the Summer CES® where retailers would get their first look at new products.

Today, however, there is less seasonality to the industry's sales cycle. With the proliferation of categories and the rapid pace of innovation, new products are introduced throughout the calendar year. EIA/CEG now sponsors two Consumer Electronic Shows® (CES®) each year. The Winter CES® is held in Las Vegas, Nevada each January, and the Summer CES® continues to be held in Chicago in early summer. For the first time ever in the 25-year history of the CES®, the general public will be admitted to the 1992 International Summer Consumer Electronics Show®. Both the Winter CES® and the Summer CES® are viewed as equally important venues for showcasing new products.

TELECOMMUNICATIONS TIA INDUSTRY ASSOCIATION

: Bringing Advanced Telecommunications Technology to the World



Government Relations

Working through domestic and foreign governments, and with the cooperation of international organizations, TIA represents the interests of its members on issues of vital importance to the telecommunications industry.

Domestic & International Marketing

TIA sponsors and participates in premier trade events worldwide. Its SUPERCOMM event, co-sponsored with the U.S. Telephone Association, is the largest annual telecommunications event in the world.

SUPERCOMM

Upcoming events include:

- ***SUPERCOMM 93***
  Atlanta, April 19-22, 1993
- ***SUPERCOMM 94***
  New Orleans, May 2-5, 1994
- ***SUPERCOMM 95***
  Anaheim, March 20-23, 1995
- ***TELECOM 95***
  Geneva, Switzerland, October 3-11, 1995

Standards Development

Through its product sector divisions, TIA helps create standards for telecommunications products, domestically and internationally.

As improved communications draw the world closer, compatible standards become increasingly important.

Information Resource

TIA regularly organizes and sponsors educational seminars and programs on critical issues in telecommunications. Through its monthly publication "Industry Pulse," members stay informed of association activities. TIA also maintains computerized databanks on products, industry sales, and member profiles.

Roadrunners International

Sponsored and funded by TIA, Roadrunners International keeps members abreast of human interest issues. This service organization provides information to its nearly 4,000 members on job openings, promotions, appointments, retirements, illnesses and deaths.

TELECOMMUNICATIONS TIA INDUSTRY ASSOCIATION

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Representing the telecommunications industry in association with the Electronic Industries Association

The Voice of the Telecommunications Industry

2 Communications Equipment and Services

The electronic communications industry is continually changing as users take advantage of new technologies and applications for transmitting all types of information—voice, data, and video. Businesses have taken hold of the progress in communications, moving from predominantly voice communications via telephone to videoconferencing, by which entire groups can interact without leaving their offices. Throughout the 1990s, businesses and consumers will continue to experience the merging of communications, data processing, computers, and consumer products, which will translate into new and more sophisticated types of data communications, office automation, and multimedia/interactive products. Also, as standards in new technologies, such as Integrated Services Digital Network (ISDN), become established, the industry—indeed, the world—will continue to move towards globally connected networks that readily transmit voice, data, and video signals.

The communications market is a strong segment of the entire electronics industry, due to its constantly changing technologies and standards that push the market further and further. In 1992, total worldwide communications revenue is expected to reach $83.7 billion, up 15% from 1991, according to *Electronics*. The United States market will account for $35.8 billion of this total, while Europe will account for $35.9 billion, and Japan, $12 billion.

Changes in the types of communication media also have impacted the size and scope of the market. Satellites, microwaves, and cellular radio allow both mobile communication and long-distance transmission without cabling. Digital technology provides faster, more reliable transmission as does fiber optics, which uses glass or plastic cables to transmit electronic signals. Each of these changes has added to the growing list of potential electronic communications technology users.

The electronic communications industry can be loosely categorized by the media used to transmit messages, the equipment used to manage transmission, and the technology used by the equipment and the media. This chapter presents an overview of these categories; however, it cannot cover the entire industry in depth. For additional information on data

Factory Shipments of Communications Equipment ($ Million); United States, 1982-1991 TABLE 2-1

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Telecommunications Equipment										
Commercial, Industrial and Military Telecommunications Equipment	6,668.6	7,542.1	9,157.5	10,606.5	11,124.6	11,394.7	12,212.7	14,016.3	15,009.8	15,940.1
Broadcast, Studio, and Related Electronic Equipment	1,543.8	1,464.0	1,475.8	1,581.9	1,553.5	1,608.4	1,804.3	1,809.6	1,820.4	1,933.2
Intercommunications Systems	324.6	176.1	212.6	172.6	195.2	282.8	392.6	367.8	343.6	364.9
Telephone and Telegraph Equipment	11,613.2	11,594.3	14,340.9	16,126.9	15,554.1	15,995.3	16,055.2	14,743.0	15,222.2	16,165.7
Fiber Optic Cable	na	na	822.3	740.8	857.5	628.6	648.6	651.8	712.6	756.7
Other Communications Equipment										
Search and Detection, Navigation and Guidance Systems, and Equipment	17,733.0	19,981.7	22,822.6	27,057.0	29,921.1	31,425.6	31,689.0	31,258.4	32,644.5	30,842.0
Alarm and Traffic Control Systems	1,246.6	1,360.6	1,519.4	1,570.0	1,474.4	1,661.4	1,551.7	1,583.6	1,489.4	1,407.2
TOTAL	39,129.8	42,118.8	50,351.1r	57,835.7r	60,480.4r	62,996.8r	64,354.1r	64,430.6	67,242.5	67,410.0

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not Available.
SOURCE: U.S. Department of Commerce.

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communications, please see the next chapter, Computers and Industrial Electronics.

COMMON CARRIER BUSINESS

The Common Carrier Business involves probably the most well-known aspect of telecommunications—the telephone companies. These companies offer a wide range of services from basic "dial tone" to online database access, packet switching, videoconferencing, and private networks. The telecommunications services consist of local exchange networks, which offer local phone service; interexchange networks offering long distance services; information services such as online data bases; special data communication services such as private packet switching; cellular services; and voice messaging and call processing.

According to the North American Telecommunications Association (NATA), the total market for telecommunications services reached $137 billion in 1990. Of that amount, local exchange services accounted for $58 billion and long distance services for $52 billion, while the other sectors accounted for $26 billion. NATA forecasts the entire market to reach $175 billion by 1995, with most of the growth expected to be in long distance (especially 800 and 900 services), cellular, voice messaging, and audiotext.

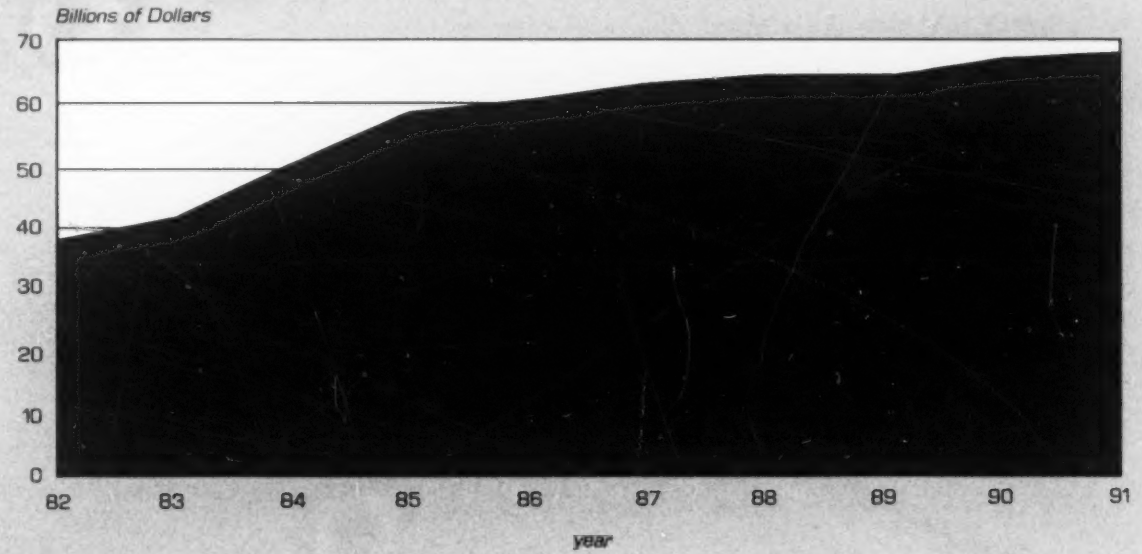
During 1991, more than 467.9 billion telephone calls were placed over the U.S. public network, of which almost 85% were local. On average, each person made about 2,200 calls a year, or more than six a day. The U.S. Bureau of Census currently reports more than 93% of U.S. households have telephones and the United States Telephone Association reports that the total number of access lines, including business and residential, hit 138 million in 1990.

Most of the world's telephone systems are to some degree government controlled or regulated. In the United States, however, the regulating entity is an independent regulatory agency called the Federal Communications Commission (FCC). The FCC, subject to Congressional legislation and appointed by the President, regulates all commercial interstate and international communications activities. Intrastate and local activities are regulated through state public utility commissions, but the initiative for new service and new pricing remains in the hands of the independent carriers.

In the United States, the telecommunications services industry is undergoing a major restructuring to accommodate the rapidly changing technological and competitive environment. In addition to changes brought about by the divestiture and reorganization of AT&T in 1984, many of the large independent telephone companies have expanded their operations to include cellular radio, fiber optics, satellite services, digital electronic mail systems, and other data communications.

Computer firms have also recognized that information systems must handle text, voice, images, and graphics—not just data processing. Modern business information systems rely on a combination of computer and communications technologies. Various computer, communications, and semiconductor companies are finding it mutually advantageous to combine their technologies through joint ventures, investments, licensing, and other cooperative arrangements. As international barriers erode, more and more joint ventures and alliances are taking place in the international arena. In the years ahead,

Annual Factory Shipments of Communications Equipment ($Billion); United States, 1982-1991 FIGURE 2-A



SOURCE: U.S. Department of Commerce, see Table 2-1 for further breakout.

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Factory Shipments of Telecommunications Equipment ($ Million); United States, 1982-1991

TABLE 2-2

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Commercial, Industrial, and Military Communications Equipment										
Fiber optics and other light systems and equipment (including infra-red)	195.1	412.3	715.6	1,013.4	945.4	726.5	717.1	772.5	1,005.6	1,068.0
Receivers, radio communications (except amateur and Citizens Radio)	1,290.3	1,390.6	1,678.1	1,952.7	2,001.4	1,764.2	1,761.7	1,976.5	2,114.8	2,245.9
Carrier current communications systems and equipment n.e.c.	161.2	220.0	116.8	136.5	140.4	127.1	182.7	186.6	148.7	157.9
Space satellite communications systems	1,614.4	1,759.7	2,277.4	2,281.4	2,391.7	2,224.3	2,386.7	2,465.0	2,545.5	2,703.2
Telemetering systems and equipment	192.1	304.0	246.1	358.1	376.8	378.7	323.9	221.3	204.3	217.0
Mobile radio systems	217.6	213.9	283.2	228.6	361.0	630.2	747.1	1,036.5	1,249.4	1,326.8
Mobile base stations	216.0	187.7	199.3	217.1	354.2	326.2	472.9	919.3	827.7	879.0
Mobile vehicular transmitters/ receivers	426.9	426.9	612.3	678.8	432.2	706.9	760.4	903.3	956.8	1,016.1
Portable receivers, transceivers and transmitter-receivers	510.2	535.5	716.5	648.4	778.6	926.2	1,420.2	1,447.3	2,011.1	2,135.7
Amateur and Citizens communications equipment	12.5	7.3	7.3	9.5	9.2	na	21.9	24.0	24.8	26.3
Checkout, monitoring, evaluation and other electronic support equipment for communications systems	182.6	241.7	251.8	241.4	277.1	316.3	304.0	211.1	184.0	195.5
Communications antennae, below 890 megahertz	140.6	129.1	107.8	110.6	134.1	159.8	180.6	198.7	197.2	209.4
Microwave antenna systems	147.6	145.8	161.7	168.3	209.3	254.6	278.4	312.5	351.2	373.0
Other communications equipment	1,361.5	1,567.6	1,783.6	2,561.7	2,713.2	2,853.7	2,655.1	3,341.8	3,188.6	3,386.2
Broadcast, Studio and Related Electronic Equipment										
Audio equipment	174.0	186.5	219.3	209.8	209.4	276.6	316.8	412.6	395.0	419.5
Video equipment	480.9	461.2	496.2	509.3	527.0	501.3	595.5	479.9	460.0	488.5
Transmitters, RF power amplifiers and related equipment	127.1	111.4	107.3	135.1	122.2	124.4	128.1	104.5	123.5	131.1
Studio transmitter links (STL) and remote pickup equipment	18.6	41.5	7.9	18.8	17.4	16.6	43.3	20.8	25.0	26.5
Cable TV equipment	459.4	452.5	410.4	375.2	382.7	327.0	423.5	540.6	560.4	595.1
Closed circuit TV equipment	123.3	99.2	109.3	125.2	141.1	95.8	135.3	144.8	163.6	173 7
Broadcasting transmitting antennae and community antennae	74.6	49.1	38.2	94.7	60.3	50.0	45.2	11.4	11.3	12.0
Other communications equipment (broadcast, studio, theater and commercial sound equipment)	85.9	62.6	87.2	93.8	93.4	216.7	116.6	95.1	81.6	86.6
Intercommunications Systems										
Intercommunications equipment electronically amplified	324.6	176.1	212.6	172.6	195.2	282.8	392.6	367.8	343.6	364.9
Telephone and Telegraph Equipment										
Private branch exchange equipment	1,047.8	1,050.1	1,603.7	1,720.8	855.9	1,412.3	1,011.2	909.3	915.6	972.3
Central office switching equipment	1,958.9	2,218.5	2,856.9	4,332.8	4,472.3	4,550.4	4,925.4	4,439.2	4,652.1	4,940.4
Other switching and switchboard equipment	1,441.2	1,382.1	1,410.6	1,660.7	1,851.9	1,404.5	1,463.1	1,627.0	1,983.4	2,106.3
Carrier line equipment	1,563.4	1,488.5	1,917.3	2,329.5	2,833.0	3,720.3	4,342.5	3,590.4	3,507.4	3,724.8
Telephone sets	1,064.9	831.2	846.7	1,218.6	790.6	299.9	346.0	345.7	223.3	237.1
Teleprinters	334.0	387.2	294.1	270.8	361.2	na	na	na	na	na
Modems	655.6	791.2	848.3	829.5	1,229.2	1,291.4	1,246.5	1,115.4	1,277.3	1,356.4
Voice frequency equipment	213.5	227.9	301.7	328.3	243.0	175.0	155.5	90.2	90.8	96.5
Answering devices	na	na	na	na	na	96.1	36.7	33.9	31.2	33.2
Key systems	na	na	na	na	na	622.0	422.3	344.0	313.5	333.0
Facsimile equipment	185.5	151.7	100.2	64.4	59.5	108.6	202.0	195.6	196.6	208.8
Other telephone and telegraph equipment and parts	3,148.4	3,065.9	4,161.4	3,371.5	2,857.5	2,314.8	1,904.0	2,052.4	2,031.1	2,157.0
Fiber Optic and Coaxial Cable										
Insulated optical fiber cable	na	na	822.3	740.8	657.5	628.6	648.6	651.8	712.6	756.7
Total	20,150.2	20,776.5	26,009.1	29,208.7	29,084.9	29,909.8	31,113.4	31,588.6r	33,108.6	35,160.6

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not Available.
SOURCE: U.S. Department of Commerce.

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global connectivity should be a major force for telecommunications growth.

According to *High Technology*, gaining network control has become a priority for some companies who want to establish and maintain reliable voice and data links. Before divestiture in 1984, the "bypass" phenomenon was not possible, as customers could not independently reconfigure the network to meet changing demands. Now, however, some companies are establishing digital links to bypass parts of the public telecommunications network, thus circumventing access charges levied by local phone companies on long-distance carriers. The most common approach is the "service bypass," which involves sidestepping the local analog links by leasing multiplexers (i.e. digital T1 links) from the local phone company. Applicable to long-haul and local needs, T1 integrates voice, data, video, facsimile, and graphics in a single high-speed facility. Now, many companies are moving from complete service bypass to hybrid services that mix public and

Factory Shipments of Other Communications Equipment ($ Million); United States, 1982-1991

TABLE 2-3

	1982	1983	1984	1985	1986	1987	1988	1989r	1990e	1991e
Search and Detection, Navigation and Guidance Systems and Equipment										
Light reconnaissance and surveillance systems and equipment including checkout, monitoring, evaluations and other support equipment	1,641.1	1,666.3	2,225.6	2,410.5	2,824.7	2,739.9	2,865.9	2,592.1	2,410.9	2,277.8
IFF equipment	94.0	151.5	174.0	156.3	155.5	226.8	287.7	288.8	219.8	207.7
Proximity fuses	154.4	209.9	259.6	196.9	281.3	234.6	300.6	359.9	367.9	347.6
Radar systems and equipment	2,441.5	3,344.3	3,698.8	4,321.0	4,625.3	3,751.4	3,658.8	3,645.8	3,640.9	3,439.9
Tracking radar	1,779.1	2,088.4	1,820.5	2,207.5	2,452.2	2,900.4	2,915.6	3,312.6	3,327.9	3,144.2
Instrumentation radar	101.4	74.1	200.6	226.3	185.4	201.9	221.4	147.1	222.6	210.3
Checkout, monitoring, evaluation and other support equipment for radar systems	267.0	329.2	435.0	474.4	445.9	479.9	453.6	331.0	358.0	338.2
Sonar search, detection and tracking systems and equipment	1,155.5	1,374.2	1,620.0	1,885.3	1,933.8	1,835.0	1,735.6	1,801.9	2,445.6	2,310.5
Checkout, monitoring, evaluation, etc. for sonar	259.7	287.8	250.6	333.9	402.0	310.9	251.7	199.6	264.8	250.1
Specialized command and control data processing and display equipment sold separately from complete systems	399.5	536.7	921.4	977.0	1,127.9	1,505.9	1,519.0	1,269.3	1,295.5	1,223.9
Meteorological electronics equipment, and radio astronomy equipment	67.6	78.7	85.7	127.5	213.2	292.5	361.6	218.0	236.0	222.9
Geophysical electronic equipment	351.6	228.5	316.4	311.1	204.2	222.1	181.6	194.2	229.3	216.7
Search, detection, identification and tracking systems, n.e.c.	1,047.8	1,189.4	1,510.0	1,961.1	1,953.4	1,964.0	1,784.0	1,799.4	1,620.5	1,531.1
Missiles-borne and space-vehicle-borne equipment	1,867.2	1,855.9	2,204.9	2,731.9	3,410.3	4,169.4	4,452.9	4,317.1	4,638.9	4,382.8
Non-missile and space vehicle guidance	394.6	420.2	480.2	508.3	536.5	540.7	482.7	736.7	758.6	716.7
Checkout, launching and other missile and space vehicle support systems	392.5	490.1	468.5	765.1	705.6	654.5	629.4	443.1	516.1	487.6
Counter measures equipment (includes jamming and underwater equipment)	1,283.5	1,595.8	2,036.5	2,682.1	3,089.6	3,527.1	3,314.7	2,838.2	2,806.1	2,651.1
Specialized electronic and communication intelligence equipment	1,345.9	1,349.1	1,370.2	1,809.5	1,895.4	2,049.1	2,271.7	2,197.9	2,467.2	2,330.9
Navigation systems and equipment for aircraft, ship, and ground navigation (autopilots, beacons, collision warning devices, direction finders, etc.)	2,689.1	2,711.6	2,744.1	2,971.3	3,478.9	3,819.5	4,000.5	4,565.7	4,818.1	4,552.1
Alarm and Traffic Control Systems										
Alarm systems (includes intrusion and fire detection equipment)	833.5	879.6	1,045.2	1,114.3	1,028.2	1,235.0	1,184.7	1,132.5	1,019.4	963.1
Traffic control equipment (vehicular and pedestrian, railway signals and attachments)	413.1	481.0	474.2	455.7	446.2	426.4	387.0	451.1	470.0	444.1
Total	18,979.6	21,342.3	24,342.0	28,627.0	31,395.5	33,087.0	33,240.7	32,842.0	34,133.9	32,249.4

r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

private networks and equipment. (For more information, see the section on Metropolitan Area Networks which appears later in this chapter.)

TELECOMMUNICATIONS EQUIPMENT

The telephone and telegraph equipment industry consists of network equipment and customer premises equipment (CPE), which are the means of transmission and the terminal equipment that sends and receives information, respectively. Network equipment includes switching and switchboard equipment, multiplexing equipment, repeaters, line conditioning equipment, and wire; these are purchased by public and private network operators. CPE includes privately owned equipment such as telephone sets, key systems, private branch exchanges (PBXs), facsimile machines, telephone answering devices (TADs), and modems. According to *U.S. Industrial Outlook '92*, U.S. shipments of total telephone and telegraph equipment reached $14.4 billion in 1990.

U.S. PBX Market, Estimated Manufacturer's Shipments[1] (Thousands of Units) 1981-1990 TABLE 2-4

YEAR	UNITS (THOUSANDS)
1981	2,865
1982	3,080
1983	3,270
1984	3,790
1985	4,115
1986	4,140
1987	4,175
1988	4,319
1989	4,201
1990r	4,005

[1]Includes shipments at the original equipment manufacturers' level intended for the U.S. market, including imports.
r-Revised.
SOURCE: North American Telecommunications Association.

CUSTOMER PREMISES EQUIPMENT

PBX, Centrex and Key Systems

Private Branch Exchange (PBX), Centrex, and key systems fall under the category of on-premises switching equipment. Centrex is leased through a Regional Bell Operating Company (RBOC) and operated offsite by the telephone company's central office, while PBXs and key systems either are leased or purchased to be operated in-house. Key telephone systems are usually used in small- to medium-sized offices with 2 to 120 station sets and provide intra-office links, such as intercoms, but route outside calls through a central operator. Key systems may be used alone or to complement Centrex or PBX systems, which are much more powerful, having more lines and allowing outside callers to dial directly. PBX and Centrex systems offer many of the same functions, the main difference being the location of the equipment and services.

The PBX market, which was deregulated in 1968, has experienced enormous technological changes in the past two decades. Moving from electromechanical to analog to digital technology, the switching systems can now operate at data speeds up to 64 kilobits per second and support MPU-based (Microprocessing Unit) telephones. PBXs offer features such as integrated call distributors, cost accounting, voice messaging, full data communications capability, and the ability to bridge local area networks. The newest machines also offer forward compatibility for Integrated Services Digital Network (ISDN). (See the ISDN section of this chapter.)

The North American Telecommunications Association (NATA) predicts renewed growth for the PBX market as older systems are replaced and ISDN increases demand. Although the market has grown slowly since a buying spree in 1984 and 1985, NATA predicts system sales to grow from $2.6 billion (26,400 units) in 1991 to $3.4 billion (32,000 units) by 1995.

Centrex demand, which had levelled off in the 1970s and early 1980s, has also started a revival. After the divestiture of AT&T in 1984, the RBOCs started to actively market Centrex services with enhanced digital features, including ISDN compatibility. The market is expected to grow 10.9% annually through 1996, according to Market Intelligence Research Corporation (MIRC). The market for key systems, meanwhile, is expected to grow at a much slower pace. NATA forecasts 5.8 million stations, valued at $1.3 billion, to be sold in 1995. In 1990, the total was 4.3 million stations ($1.025 billion value), only a slight increase from the 1985 total of 4.2 million stations, valued at $995 million. NATA expects key systems using Centrex—most likely 1 to 24 lines—to grow the fastest.

Voice Processing Equipment

One of the largest telecommunications equipment growth areas in the past few years has been voice or call processing equipment. The market reached $2.21 billion in 1990, up 39% from $1.59 billion in 1989. Through 1995, the market is expected to experience a compound annual growth rate of 14.6%, hitting $4.5 billion in 1995, according to NATA.

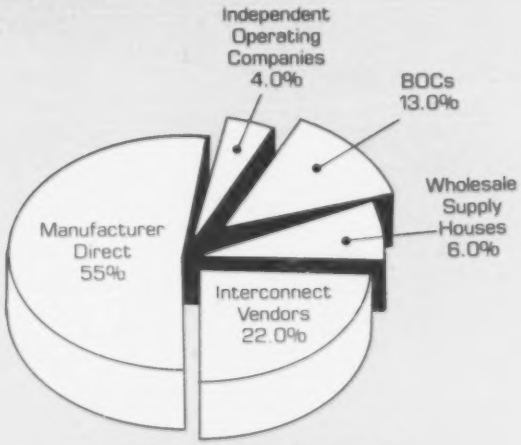
The call processing equipment market can be divided into voice mail or messaging, voice response systems, automatic call distributors, and automatic dialers (used mainly in telemarketing). The fastest growing element is voice mail/response equipment, which can be either a stand-alone system or an optional feature on a PBX. Venture Development Corporation expects the entire voice mail/response industry to grow steadily through the early 1990s, reaching $3.8 billion in annual revenues by 1994; the impetus for growth is attributed to a second wave of demand from business users looking for specialized and sophisticated applications.

Voice response systems take voice mail one step further by incorporating other equipment, such as automatic attendants

and database management equipment, to provide automated call processing functions. Typically, integrated voice response systems consist of hardware and software customized for an individual customer or types of customers. The result is either an interactive or noninteractive system that gives a caller several options from which to choose, accesses a database based on the caller's selection, and provides verbal information from the database to the caller. An interactive system could allow bank transactions, for example, while a noninteractive system would merely provide information to the caller.

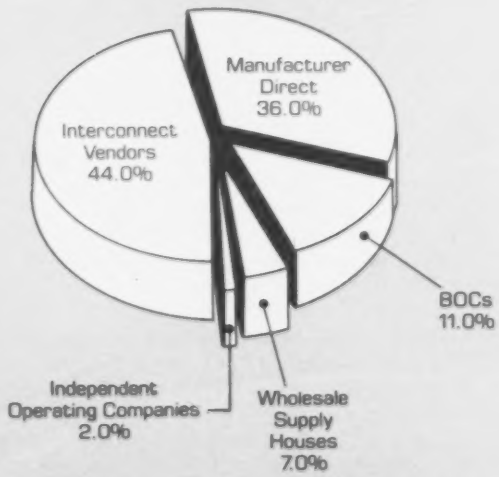
PBX Shipments by Manufacturers' Distribution Channel: 1990

FIGURE 2-B



Total Shipments: 4.0 Million Lines

Key & Hybrid Shipments By Manufacturers' Distribution Channel: 1990



Total Shipments: 4.3 Million Stations

SOURCE: North American Telecommunications Association.

Telephones and Answering Devices

The telephone market remains steady, even though household penetration is high, over 93%. The Electronic Industries Association (EIA) estimates 1991 total factory sales of corded and cordless phones at $1.83 billion and predicts a $1.89 billion market in 1992, with growth in the cordless market counteracting a drop in corded phones.

Telephone answering devices (TADs) should generate interest in the next few years. As of January 1992, 46% of 94.6 million U.S. households had TADs. However, with the coming of tapeless digital telephone answering devices (DTADs), the future is hard to predict. The DTAD market depends on several factors, including price and sound quality. Prices will continue to become more competitive as the number of available products grow and the price of memory devices declines. In regard to audio quality, digital chips have improved greatly since 1988 and more manufacturers are considering DTADs as the up-and-coming product. One digital chip supplier is forecasting worldwide DTAD demand to grow from 400,000 units in 1990 to 13.1 million units by 1993, accounting for almost 35% of the total TAD market.

Introduced in 1989, Caller ID allows phone users to identify the name and/or phone number of callers before picking up the receiver. As of year-end 1991, 20 states offered Caller ID services, currently only available intrastate. However, Congress is expected to pass a national standard mandating per call blocking, which would possibly encourage more states to consider Caller ID and clear the way for the workings of interstate services. The market for home office/small business Caller ID units appears wide open for future growth: nationally 5% of small businesses already use Caller ID. According to Jupiter Communications, of those now using the service for business, 67% say it improves business efficiency, while 13% say it has no effect on their business.

Meanwhile, the market for payphones has shown enormous growth since the 1984 FCC ruling that allowed businesses other than phone companies to connect payphones to the interstate network. NATA reports that the annual payphone market grew from $35 million in 1984 to $222 million in 1990.

Facsimile and Modems

Facsimile devices (or fax machines) are grouped into categories by transmission speed. Group 1 & 2 standards, established in the 1960s, describe very slow transmission speeds by today's Group 3 standards. (Group 1 machines require six minutes per page compared to one minute or less per page for Group 3.) Group 3 products created the mass market by having a high-enough performance level for speed and resolution without degrading reliability or adding an unreasonable cost burden. The Group 3 standard has been adopted on an international basis, allowing for mass production and the associated economies of scale that have contributed to lower costs. At present, Group 4 machines, which transmit one page in only a few seconds, are geared for wideband communication lines and high-volume use by large companies. Their growth will be enhanced by the Integrated Services Digital Network (ISDN) that is expected to become functional by the mid- to late-90s, as well as by the expansion of the user base via price reductions.

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U.S. PBX-Centrex Market, Installed Base Development[1] (Thousands of Units); 1986-1990 TABLE 2-5

	1986	1987	1988	1989	1990
TOTAL PBX	24,379	25,314r	25,897	25,145	25,200
TOTAL CENTREX	7,355	7,525	8,100	8,223	8,616
TOTAL PBX-CENTREX	31,734	32,839r	33,997	33,368	33,816

[1]Installed base refers to the cumulative total of instruments (telephone handsets or equipped lines) in use at the end of each calendar year.
r-Revised.
SOURCE: North American Telecommunications Association.

Lower costs combined with better quality transmissions have made the fax market a prime growth area. Total fax machine installation in businesses and households have reached 5 million, and will grow to more than 10 million by 1994, according to BIS Strategic Decisions. The firm predicts total U.S. sales will grow to 2.5 million units by 1994, up from 1.5 million units in 1990. However, due to the decreasing average cost of fax machines and a larger percentage of fax sales from lower end units, dollar sales are expected to drop to less than $1.8 billion by 1994, from $2.2 billion in 1990.

Even with affordable prices, however, fax machines have yet to reach mass market. Prerequisites of the development of a large home fax market include a range of legitimate consumer applications and a base of residential fax users.

"Plain paper" faxes are solving a frequent complaint of fax users—the slick thermal paper whose printed impressions fade over time. Annual sales of plain paper fax machines are expected to grow from approximately 600,000 units a year in 1991 to more than a million units by 1994, according to BIS.

U.S. Key Telephone Market, Estimated Manufacturer's Shipments[1] (Thousands of Units and $ Millions); 1981-1990 TABLE 2-6

YEAR	UNITS (THOUSANDS)	DOLLARS (MILLIONS)
1981	2,900	870
1982	3,050	915
1983	3,350	921
1984	4,240	1,039
1985	4,150	955
1986	4,199	957
1987	4,259	960
1988	4,260	965
1989	4,275	995
1990r	4,295	1,025

[1]Includes shipments at the original equipment manufacturers' level intended for the U.S. market, including imports.
r-Revised.
SOURCE: North American Telecommunications Association.

The majority of these buyers will be corporate and small business users, but as prices decline, the home office market will open up. Another area showing promise is the five-year-old portable or mobile fax market, which operates through cellular phone equipment. The *Journal of the Electronics Industry* estimates 1991 U.S. sales of portable faxes between 25,000 and 40,000 units. The expanding market is attributed to a new commitment from suppliers, as well as manufacturers entering the market. Current users of portable faxes include police officers, fire fighters, and delivery services; the market should continue to grow as other potential users, such as attorneys and salespeople, start to buy.

Along with traditional fax terminals, products such as fax boards, fax servers, and fax switches, are also gaining wide spread use. The use of fax boards in personal computers is accelerating to improve the graphics quality and speed of faxed materials. Fax board sales increased from 92,000 units in 1989 to 179,000 units in 1990, according to NATA. Fax servers allow LAN users to share fax gateways while fax switches allow users to have one line for both voice and fax traffic, allowing small businesses to keep the number of telephone lines to a minimum.

Modems, which permit computers to exchange data over telephone lines, will become obsolete once all digital networks become commonplace. For now, however, sales of modems continue to increase and most likely will do so for at least ten more years. The Computer and Business Equipment Manufacturers Association (CBEMA) estimates 1990 U.S. shipments of modems at 2.7 million units, projected to grow 11% in 1991 to 3.1 million units. By the year 2001, CBEMA expects unit shipments to reach 4.8 million units. At the same time, however, annual revenue is expected to drop at an average annual rate of 3.9% as the average unit price falls.

VIDEOCONFERENCING

Videoconferencing, a communications system that allows users to transmit video images and accompanying audio between two or more locations, is beginning to be widely used by businesses. Videoconferencing allows companies to maximize productivity by being able to cut travel expenses, travel risks, and wear and tear on employees. During 1991, the Persian Gulf War contributed to widespread use of the sys-

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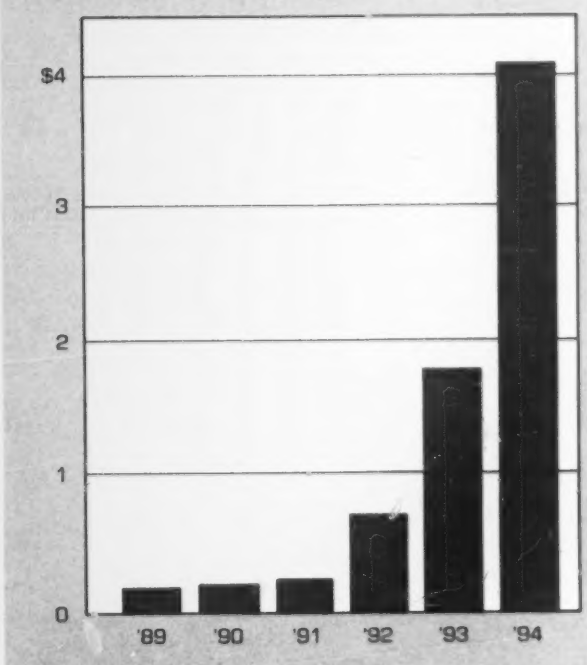
tems. Standards have been implemented; prices have dropped dramatically to less than $25,000; voice and picture quality have improved; and network providers are offering cheaper digital services. Analysts still are uncertain about potential market size, however, offering conflicting forecasts. One research company predicts the market will hit $239 million in 1995, nearly 100% growth from an estimated $120 million in 1991. Another firm is even more hopeful, forecasting sales to reach $300 million in 1992, up from $185 million in 1991.

SATELLITE COMMUNICATIONS

Satellite communications consist of a space segment, essentially the communications satellite; a ground segment, made up of earth stations for transmitting and receiving signals; and equipment for tracking, telemetry and control (TT&C) of the satellites in orbit. The communications satellite is basically a sun-powered microwave radio receiver and broadcast unit placed in orbit to receive carefully aimed radio signals from an earth station transmitter and transmit them back to earth. On the ground, a receiving dish collects and concentrates the signals, then amplifies them to the power levels required by telephone, television, or other end equipment.

Mobile Satellite Systems Worldwide Revenue ($ Billions) FIGURE 2-C



SOURCE: Gartner Group

Communications satellites are placed in a stationary orbit over the equator; those located from 83 degrees to 135 degrees west longitude cover the western hemisphere. *Via Satellite* lists the top events of 1991 in the industry as the use of satellites during the Persian Gulf War, the defeat of user fees, continued trends toward deregulation, and the advent of significant commercial low-earth orbit satellite system proposals.

During 1991, the satellite industry continued to progress through a period of renewed growth, following several years of setbacks from satellite launch failures. According to *U.S. Industrial Outlook '92*, U.S. manufacturers delivered nine commercial communications satellites, valued at approximately $1.3 billion although the number of satellites remained constant with the 1990 level, three of those delivered in 1991 were more powerful, more expensive satellites used by international organizations. Ten satellites are scheduled for delivery in 1992, 12 in 1993, and 13 are on order for 1994. Worldwide 57 satellites are scheduled for delivery between 1992 and 1997 by U.S. companies, of which 24 are for domestic customers.

As with the space market, the ground segment of satellite communications offers myriad opportunities for growth. *U.S. Industrial Outlook '92* estimated sales of satellite ground equipment were $1.3 billion in 1991, up from $860 million in 1990. After several years of dominance by broadcasting and cable applications, the earth station sector is turning to new market areas such as Very Small Aperture Terminal (VSAT) networks, Television Receive Only (TVRO), Direct Broadcast Satellites (DBS), and Mobile Satellite Systems (MSS).

VSAT networks, reports *Satellite Retailer*, connect various locations through small antennas on terminals aimed at the same communications satellite. The networks completely bypass existing transmission systems; all communications are through the VSAT network controlled by a larger "hub terminal." The advantages of VSAT networks, according to *Satellite Retailer*, include "low cost per location, full digital compatibility, excellent reliability, flexibility, fast reconfiguration, and easy expansion." In 1991 VSAT network equipment revenues stood at $700 million, with 21 systems installed, and nearly 6,000 terminals shipped, according to *U.S. Industrial Outlook '92*. Analysts predict similar growth in Europe and Latin America as regulations change to encourage growth in the telecommunications arena.

Mobile Satellite Systems (MSS) are characterized by small, easily-mounted terminals on land, sea, or air vehicles. The systems are ideal for field communications and for navigation, paging, and location information. As an example, the trucking industry is increasingly using MSS to track truck locations and communicate with drivers. MSS offer tremendous growth opportunities for the next three to five years, spurred by smaller and substantially less expensive receivers. The Gartner Group forecasts a 150% compound annual growth rate from 1990 to 1995, which means the number of terminals is expected to increase from 20,000 to 2 million (see Figure 2-C).

Meanwhile, Television Receive Only satellites (TVROs) continue to compete with cable television services. EIA predicts 1992 factory shipments of TVROs to reach 310,000 units valued at $421 million, up from an estimated 320,000 units valued at $408 million in 1991. Widespread introduction of Direct Broadcasting Satellite (DBS) services could push the growth in TVRO sales. In 1991, high-powered DBS services were not yet operational in the U.S. market, but lower-pow-

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ered services utilizing satellites already in orbit were introduced in limited markets. Eight U.S. companies were conditionally licensed by the FCC for "true" high-powered DBS services in 1991; the earliest service is planned for 1994. With some services offering more than 100 channels and customer equipment costs dropping to about $700 per receiver, DBS could push annual sales growth of TVROs to 20% by the mid-1990s, according to *U.S. Industrial Outlook '92*.

MICROWAVE TRANSMISSION

Microwave transmission, a term used to describe the use of frequencies of 1 GHz or more, is an economical means of moving large amounts of voice, video, and data signals from point to point, either terrestrially or via satellite. First used commercially in the United States in 1945, microwave transmission now provides a wide range of communication services, including television, radio, telephone, telegraph, facsimile, and data transmission.

The traditional use of microwave systems in long-haul paths of up to 40 miles is gradually being discarded in favor of short-haul, high frequency systems in the 18 GHz or 23 GHz range. The short-haul microwave systems offer an advantage over fiber optic and satellite since they can be installed inexpensively and easily. Recently, microwave systems have found a niche in both high-frequency urban markets and less accessible rural markets. *Business Communications Review* reports that microwave systems are also becoming a popular back-up technology for existing telephone systems when natural disasters or other problems temporarily disrupt services.

According to *U.S. Industrial Outlook '92*, domestic shipments of complete microwave systems were valued at $929 million in 1991, up 1% from 1990. The slight growth was due mainly to sustained equipment sales for short-haul digital systems. In fact, almost all new systems now being installed are digital rather than analog; these new installations focus on high-frequency, short-haul application, such as video distribution, urban links, wireless local area computer networks (LANs), and private networks. By 1993, digital short-haul systems are expected to grow to half of the U.S. market, overtaking the traditional long-haul analog equipment market.

The newer digital microwave transmission systems (DMTX) reduce equipment and installation costs while increasing system effectiveness, according to *Telecommunications*. DMTX systems take advantage of already installed digital switches and more readily transmit digital signals.

Users of microwave systems include the traditional common carrier sector, which makes up about 58% of the installed base; private microwave networks, representing about 18% of the market; and other users such as government agencies and broadcasting systems, 24%. Cellular phone networks use microwave systems to connect transmission "cells" and cable television companies are increasingly using Cable Antenna Relay Services (CARS) to bridge gaps between cable systems. The FCC estimates about 2,200 CARS systems licenses used microwave technology in 1991, a slight decline from last year. These markets are expected to be relatively flat over the next two years, due to market saturation and the increased use of fiber optic technology by cable system operators.

Another trend in the microwave industry is that of companies bypassing traditional public telephone networks via microwave transmission. As reported in *High Technology*, several companies sell microwave radio equipment that allows a customer to establish a direct digital link to an interchange carrier's point of presence. Although such a microwave link costs about $25,000, the payback period may be as short as two years. Microwave is a common option for facility bypass, because no companies have the right-of-way to install terrestrial cables. There are drawbacks, however, as *High Technology* reports. Microwave transmission needs a clear "line of sight" between end-points, and rain and snow tend to interfere with transmissions at frequencies higher than 11 GHz.

Also emerging in the microwave industry is the fledgling "wireless cable" industry, which relies solely on microwave transmissions to broadcast programs and is struggling to compete with cable TV. Wireless cable or multichannel, multipoint distribution service (MMDS), uses omnidirectional microwave facilities and eight- to ten-meter satellite earth stations to transmit more than 30 television channels. If "line-of-sight" is available, wireless cable is cost competitive with traditional wireline cable systems. By year-end 1991, the FCC had licensed about 100 wireless cable systems, with more than 300,000 subscribers in 24 operational systems; some 6,000 additional applications are pending at the FCC.

CELLULAR RADIO

Cellular phones, once a status symbol more than a communications medium, have finally entered mainstream America. EIA estimates factory sales of 2.1 million cellular phones in 1991, up 141% from 870,000 phones in 1990. By 1994, more than 10 million units could be in use, according to Venture Development Corporation, which forecasts 30% annual growth for the industry from 1989 to 1994. Other analysts also expect huge growth. Market Intelligence Research Corporation (MIRC) predicts the development of a digital network will give more people access to cellular phones, while, at the same time, lower prices will appeal to the consumer market and to those in sales and marketing, management, and service industries. MIRC also sees the cellular market interacting with the pager and voice mail markets. Callers can contact a cellular subscriber by leaving a message in a voice mailbox, which in turn alerts the called party via a pager. As for the number of subscribers to cellular services, the Cellular Telecommunications Industry Association (CTIA) reported the largest number of cellular subscribers to date—approximately 7.6 million, as of December 1991 (see Figure 2-D).

Cellular radio systems operate by sending radio signals to nearby transmitting stations. The limited frequencies available on radio bands are divided into cells, which are served by transceivers in each market area. When one cell becomes busy, it is divided into smaller cells using less transmission power. Cells generally serve a radius of 8 to 12 miles and can be split three times, with the minimum radius being 1 to 1.5

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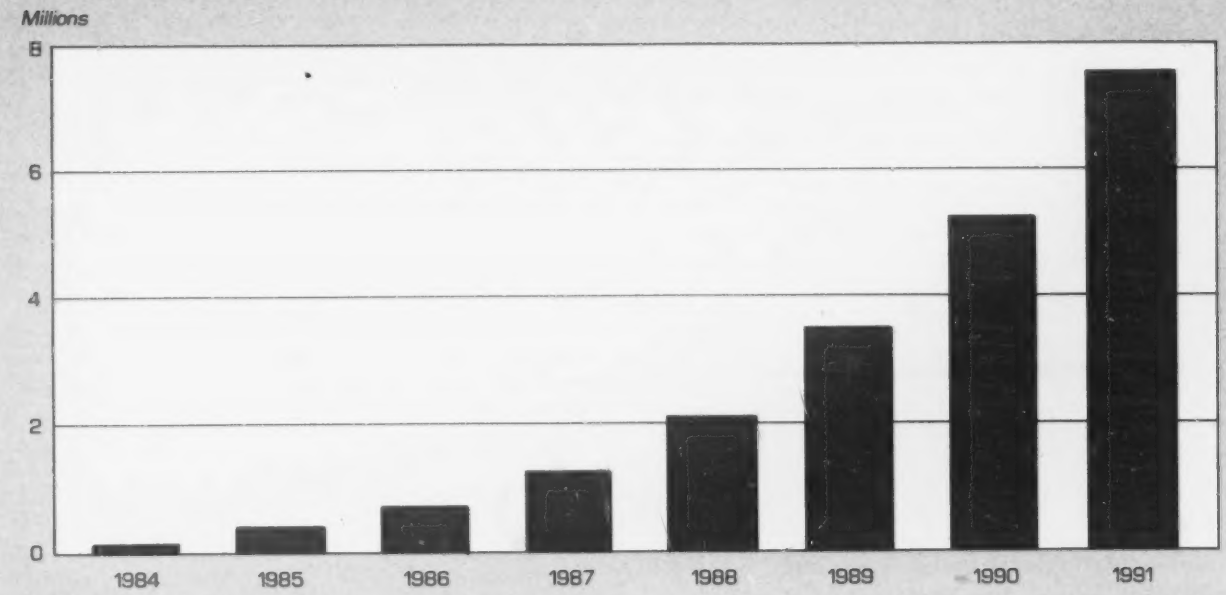
Cellular Phone Subscribers, 1984-1991 FIGURE 2-D



SOURCE: Cellular Telecommunications Industry Association.

miles. Approximately 3,000 customers per cell can be simultaneously serviced without excessive service delays.

A cellular mobile radio system consists of a mobile radio telephone, transmitter and antenna, a small base station within each of the cells into which a region is divided, and a main switch controller called the Mobile Telephone Switching Office. The FCC has allocated licenses for two cellular telephone systems in each city—one wireline to be operated by an established telephone company and one non-wireline to be operated by independent companies.

Quality of service is maintained as a user drives from one part of a city to another, even from one cell to another. As the user enters a new cell, a central microprocessor and specialized radio equipment automatically adjusts to the new cellular system without interruption. With the increasing number of subscribers, however, cellular systems are getting overcrowded. Industry experts hope conversion from analog to digital technology will relieve congestion in the near future.

New digital cellular hardware standards promoted by the CTIA are moving the industry closer to dual-mode cellular phones, which offer both analog and digital cellular communication services. Digital cellular offers numerous advantages over analog, most important of which is increasing the number of subscribers that can be supported by today's systems. Digital phones also offer such benefits as better voice quality, less crosstalk and background noise, higher data transmission rates, and better conversation security. The first markets likely to go digital will be such high density areas as Los Angeles, New York, and Chicago. Within five to eight years, digital cellular could be as widespread as the present analog system.

WIRELESS PERSONAL COMMUNICATIONS

Wireless personal communications could generate strong demand for radio communications equipment over the next five to ten years. The services receiving the most attention in this arena are personal communications networks (PCNs). However, the success of this segment rests on key decisions in the technology spectrum and licensing issues. In early December 1991, the FCC began to consider bandwidth allocation in the 1.8- to 2.3-GHz frequency range of the public radio spectrum for PCN applications. Industry watchers expect an approved band somewhere within that spectrum by mid-year 1992.

PCN technolgy utilizes personal handsets or cordless telephones that would operate in a variety of pedestrian, office, residential, and possibly vehicular settings. Using microcell technology, cells spaced about 700 yards or less apart, the equipment will require low power levels for users to communicate with base stations. Lower power requirements, in turn, permit smaller, lighter phones that cost less to buy and use. Potential operators are evaluating the technical and economic feasibility of implementing personal communications services (PCS) through experimental authorizations granted by the FCC. As a result, demand estimates range from 60 to 100 million PCS subscribers by the year 2000. Many industry analysts believe that the general business market will be the first target for wireless communications equipment. According to Alexander Resources, 19 million out of a total 115 million U.S. workers will use wireless telephones, and sales will reach $2.1 billion by 1997.

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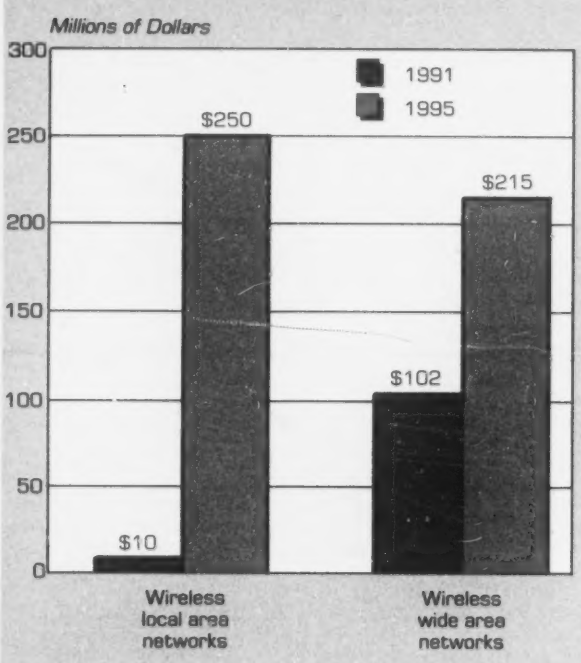
Wireless Communications Network Equipment Market FIGURE 2-E



SOURCE: Dataquest

LAND MOBILE RADIO

With the explosion of the communications industry in recent years, two-way land mobile radio services have stood out as a sector of the industry which has witnessed dramatic growth. Virtually every type of public safety agency, business, utility, transportation activity, and state and local government has come to rely on land mobile radio as an indispensable part of its operation.

Data transmission, digital modulation techniques, and nationwide satellite coverage are driving land mobile two-way radio to a $3.7 billion market from 1990 through 1994, according to Frost & Sullivan. At the same time, however, channel saturation in the major metropolitan areas is hindering growth. Although the FCC has allocated 624 additional channel pairs in the 800- and 900-MHz bands, the industry has been slow to respond, primarily because of the mandated change in bandwidth from the previously used 25 KHz to 12.5 KHz. Of the entire industry forecast, approximately $2.2 billion will go to shipments of mobile and hand-held portable radios.

While the addition of channels to the 800- and 900-MHz band will help private radio services, these additional channels will erode carrier conventional mobile radiotelephony. This, combined with the FCC's plan to extend the availability of private radio telephone interconnection to the lower UHF and VHF frequencies, could eventually bring about the demise of carrier mobile radio telephones. Common carrier radio telephone hardware is already giving way to cellular phones.

CABLE TELEVISION

Cable television, also known as Community Antenna Television (CATV), began service in 1948 to bring distant television signals to isolated communities where reception from stations was poor or nonexistent. Later, cable service was introduced in suburban areas and a few cities, where it added the programs of one or two distant stations to those available from the local stations. The higher cost of installing cable in large cities, coupled with the greater variety of local TV programs readily available, kept cable systems out of many urban markets.

Domestic communications satellites revolutionized the cable TV industry by allowing low cost distribution of programming to independent cable systems throughout the country. In the 1970s, cable services expanded from the early five to twelve channel systems to 30 to 35 channel offerings. Cable program services such as Home Box Office (HBO), The Movie Channel, and countless others were established to provide premium programming. In the 1980s, the industry grew rapidly from only one profitable cable service in 1983 (TBS, the Atlanta-based superstation) to 12 profitable services out of the 15 largest advertiser-supported programming services, according to the Cable Television Advertising Bureau (CTAB). "Three of them—TBS, Cable News Network (CNN), and ESPN—each earned more than the CBS and ABC television networks combined," cited CTAB.

In 1991, total revenues for cable television reached more than $20 billion, according to estimates from Paul Kagan Associates, $17.7 billion of which came from subscriber services and $3.01 billion from advertising. *U.S. Industrial Outlook '92* expects total revenues for the cable television industry to expand about 10.5% in 1992, with advertising revenues to gain more than subscriber services.

INTERACTIVE TELEVISION

In October 1991, the FCC accepted the concept of a "video dial tone" bringing interactive TV closer to widespread consumer reality. The FCC's decision, currently under review, will allow regional telephone companies to deliver video signals through phone lines and to enter the information service business. Final conclusions are yet to be determined but industry analysts predict the FCC decision could dramatically change broadcasting as RBOCs talk about video-on-demand, interactive video, and video gateways to databases. Yet, experts do not see widespread services until "fiber-to-the-curb" is available across the country, still a number of years from implementation (see Fiber Optics section of this chapter). Once such services are implemented, however, KMI Corporation believes one of the broadband services, video-on-demand, could be a strong competitor to video tape rentals, predicting telcos will penetrate 4.5% of the video rental market by 1996 and will increase their share to 35% by 2001. Video-on-demand could allow users to retrieve from a library

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Estimated Size of Cable Television Industry; United States, December 1991 — TABLE 2-7

Number of Cable TV Systems	1,704
Basic Cable Subscribers (Homes served)	55.8 Million
Penetration:	
Homes served as percent of homes passed by cable	64%
Homes served as percent of U.S. TV households	60.6%
Homes passed by cable	87.4 Million

SOURCE: National Cable Television Association. (CATV System from Warrun Publishing; all others from A.C. Nielsen.)

of programming at their convenience as opposed to the time restrictions of typical pay-per-view services offered today. Also, the video databases could provide computer graphics and databases to provide home-shopping catalogs. For example, users could call up the entire L.L. Bean catalog online, according to one industry follower.

The early efforts in the U.S. to achieve success in the "information service" industry via teletext (data transmitted simultaneously with television signals and decoded at the local television or terminal) and videotex (users dial into a database from a terminal or computer to receive a video display) were met with the same frustration that many new products and services experience—insufficient customer awareness. Although people within the industry saw its promise, pointing to successful European examples, the average U.S. consumer and business had little knowledge of videotext benefits. Large companies pooled resources in joint ventures to provide services but, to this day, the next wave of users (beyond the computer-literate population and other special niche areas) has not yet crested. The onset of the telcos involvement with "video dial tones" could build the awareness factor into a viable user service.

DATA COMMUNICATIONS NETWORKS

One area that epitomizes the global nature of the electronics industry is that of network equipment and services. Networks are rapidly covering the globe, connecting entire industries as well as tiny divisions within a single company. The computer and communications industries have become mutual participants in serving the world's appetite for rapid and effective use of information. As efforts toward standardization take place, the race toward digitalization, and the wide variety of products available such as telephones, data terminals, fax, telex, videotex and PCs, will help the world move towards a compatible, retrofittable environment.

As businesses and information users demand interconnectivity, the network market as a whole is growing rapidly. Frost & Sullivan expects the entire U.S. market to reach approximately $18 billion in 1993, compared to $5.7 billion in 1988. Another research firm, The Freedonia Group, projects a 33% annual increase in U.S. sales of local and wide area networking products and services through 1993, reaching a total of $14.7 billion. Networks generally can be defined based on the size of the network configuration as outlined in the following sections.

Local Area Networks

Local area networks (LANs) cover a relatively small area, ranging from several feet to a mile, and usually are within one organization or structure. During the next three years, LAN sales will continue to expand rapidly. Currently, about 40% of installed personal computers are connected to LANs. By 1993, 25.9 million personal computers will be connected to LANs worldwide, showing a 71% annual growth rate from 1990, according to Workgroup Technology. The number of fax machines connected to LANs is expected to grow even more dramatically. BIS Strategic Decisions expects a 139.7% average growth rate from 1989 to 1993, with 198,000 faxes connected to LANs by that time. Worldwide LAN hardware revenues could reach more than $10 billion in 1992, up from $8 billion in 1991, according to *U.S. Industrial Outlook '92*.

Currently, most LANs are configured using the Ethernet standard; however, as networks become overloaded with traffic, the need for high speed and clarity are turning users to two other standards, Token Ring and FDDI. Sales of Token Ring interface cards surpassed those of Ethernet cards in 1990 and will continue to do so in coming years, according to *Computer Reseller News*. Meanwhile, Fiber Distributed-Data Interface (FDDI) cards are also gaining ground. FDDI is a fairly new fiber-optic based technology that operates at extremely high speeds—100 megabits per second (mbps) compared to 10 mbps for Ethernet and 4 or 16 mbps for Token Ring. The 1991 FDDI market, including interface cards, internetworking devices and concentrators, reached $100 million, according to Dataquest. *Computer Reseller News* reports a possible worldwide market for FDDI interface cards of $163.7 million by 1994.

The LAN industry, like so many others, is beginning to market a wireless product; using cellular techniques, infrared transmission, spread spectrum technology, and GHz frequencies. Wireless LANs allow users to avoid costs associated with moving a node. Dataquest predicts the wireless LAN market will hit $250 million in 1995, up from $10 million in 1991 (see Figure 2-E).

Wide Area Networks

Wide area networks (WANs) transmit over a large geographic area—up to hundreds of miles wide. Cable, microwave, and satellite (or combinations of the three) are the equipment used by WANS to transmit data. WANs can be private networks or can use facilities of local and long distance telephone companies or other public networks. Frost & Sullivan estimates a $6.5 billion U.S. market for WANs in 1995, compared to $4 billion in 1989.

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Growth of Cable Television Industry; United States, 1982-1991 TABLE 2-8

YEAR	TELEVISION HOMES	CATV SYSTEMS	BASIC CABLE SUBSCRIBERS	PERCENT OF CABLE PENETRATION OF TV HOMES
1982	81,496,500	4,825	21,000,000	25.8
1983	83,462,600	5,600	25,000,000	30.0
1984	83,971,800	6,200	30,000,000	35.7
1985	86,400,000	6,668	37,900,000	43.9
1986	87,476,100	7,737	40,640,600	46.5
1987	88,420,260	7,836	43,529,660	49.2
1988	89,120,260	8,413	46,662,200	52.4
1989	91,192,205	9,010	50,699,000	55.6
1990	93,065,870	9,621	54,871,330	59.0
1991	92,040,450	10,704	55,786,390	60.6

SOURCE: National Cable Television Association. (CATV System from Warren Publishing; all others from A.C. Nielsen.)

Metropolitan Area Networks

Metropolitan area networks (MANs), sometimes called bypass carriers, offer businesses an alternative route to connect to long distance services. According to *Communications Week International*, MANs compete with local telephone carriers through "self-healing rings," which actually are full-circle fiber loops that offer protection against network breakdown plus fast, high-capacity, digital transmission.

As companies call for more backup protection, MANs are beginning to prosper across the United States. Kessler Marketing Intelligence expects more than 50 MANs to be operating in 35 cities by the end of 1992, up from 39 MANs operating in 25 cities at the end of 1991. Annual revenue for the companies is increasing dramatically every year, and new players are expected to begin competing in what MIRC says should be a $1.2 billion market by 1996.

INTEGRATED SERVICES DIGITAL NETWORK

ISDN is the future—in some cases, the present—of networking. The International Telecommunications Union defines ISDN as: "a network evolved from the telephony integrated digital network that provides end-to-end connectivity to support a wide range of services, including voice and non-voice services, to which users have access by a limited set of standard multipurpose customer interfaces." More simply, ISDN refers to standardized all-digital networks that process voice, data, and video communication through one system. The objective is a high-speed, cost-effective, globally compatible network.

The evolution of ISDN has been slow, starting in the early to mid-80s and still continuing today. Although RBOC-sponsored ISDN trials took place beginning in 1986, and most of the network standards now have been established, the standards for terminal equipment are still being worked out. Plans for a nationwide standard between RBOCs and switch manufacturers should be in place by year-end 1992. According to *ISDN News*, the seven Regional Bell Operating Companies have approximately 391 customers ISDN customers and over 110,000 basic rate interface (BRI) lines and 127 primary rate interface (PRI) lines, which have 20 times the capacity of BRI lines. With both network and equipment standards in place in 1992, full implementation of ISDN should be right around the corner. One industry insider believes the operating companies are targeting major conversions to begin in 1993 and 1994, with an expected 60% of all U.S. lines to be able to handle ISDN by 1994.

FIBER OPTICS

Fiber optic systems use small lightweight cables, made from glass or plastic, to transmit electronic signals between different locations. The cables are characterized by their ability to transmit huge quantities of data, voice, or video. Fiber optic cable can carry as much information as 21 1/2-inch copper cables. The fiber optic medium has an added attraction of not being susceptible to electric, electromagnetic, or radio frequency interference, thus providing enhanced signal security, important to both government and business users.

The advantages of fiber optic systems, combined with a recent trend towards lower prices, have made the industry ripe for growth. Market Intelligence Research Corporation (MIRC) expects the market for local-area fiber networks alone to grow from $55 million in 1986 to about $1 billion in 1996. Fiber-based metropolitan area networks (MANs) are expected to increase even more, from about $30 million in 1986 to $1.2 billion by 1996.

Currently, the United States has installed approximately 8.2 million fiber-kilometers for telecommunications applications. In 1991, the U.S. fiber optics market grew to $1.7 billion, up 21% from $1.4 billion in 1990, according to the U.S. Department of Commerce's *U.S. Industrial Outlook '92*. Analysts expect even more growth throughout the decade. One research firm, Leading Edge, forecasts a $4 billion-plus market by the end of the decade. KMI Corporation reports that by the year 2000, more than 40 million U.S. homes will be connected to a nationwide fiber optic subscriber loop network and predicts local telephone companies will add three million access lines of fiber in the loop (FITL) by 1996.

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Imports and Exports of Communications Equipment ($ Million); United States, 1990-1991 — TABLE 2-9

	1990	1991
IMPORTS		
Telephone Sets and Parts	1,043.6	957.6
Telephonic Apparatus and Parts	946.9	1,011.5
Telegraphic Apparatus and Parts	338.3	441.0
Radio Transmitters	71.0	65.9
Radio Receivers	184.5	171.1
Radio Transceivers	582.5	574.7
Telephone Answering Devices	312.9	296.1
TV Transmission/Reception Apparatus	1,480.3	1,211.0
Cellular Telephones	358.8	283.5
Facsimile Machines	776.6	908.3
Cordless Telephones	587.7	805.7
Smoke Detectors and Other Alarms	170.0	198.4
Modems	119.2	144.8
Sound/Sight Signaling Apparatus	14.0	15.9
Radar/Radio Navigational Equipment	721.3	798.6
Meteorological/Geophysical Instruments	7.5	8.6
Paging Alert Devices	59.1	7.2
TOTAL	7,774.2	7,899.8
EXPORTS		
Telephone Sets and Parts	199.4	203.0
Telephonic Apparatus and Parts	1,446.2	1,501.1
Telegraphic Apparatus and Parts	465.6	574.3
Radio Transmitters	311.9	333.4
Radio Receivers	286.7	211.1
Radio Transceivers	640.1	800.1
Telephone Answering Devices	91.8	112.5
TV Transmission/Reception Apparatus	1,148.0	974.5
Facsimile Machines	461.8	572.1
Cordless Telephones	76.6	89.8
Smoke Detectors and Other Alarms	134.5	155.6
Modems	327.6	331.4
Sound/Sight Signaling Apparatus	49.2	50.9
Radar/Radio Navigational Equipment	2,271.3	2,359.6
Meteorological/Geophysical Instruments	18.2	19.0
Paging Alert Devices	1.5	1.8
TOTAL	7,930.5	8,289.4

r-Revised.
SOURCE: U.S. Department of Commerce.

A huge boost for fiber optics is expected from the forthcoming Fiber Distributed Digital Interface (FDDI) standard, growing from an installed base of only 200 transceivers in 1989 to 2,800 in 1990, jumping to an expected 30,000 transceivers by the end of 1992, according to KMI Corporation. The burgeoning demand for ever-increasing masses of electronic signals—whether data, voice, video, or all of the above, will foster the growth of new products and services which will benefit all facets of our society. In the business, government, and educational communities, the various networks are heading toward further interconnection. LANs, VANs, WANs, and MANs, all exemplify this connectability trend.

One of the rapidly expanding areas in fiber optic technology is home fiber networks. As early as 1988, Heathrow, a planned city in Florida, used fiber optic cable to link all its buildings to an alarm monitoring station and to telephone and cable services. More recently, several European countries have started to work on trial fiber optic networks, linking homes and offices to such services as television channels, stereo audio channels, telephone, a video library, and videotext. These trials will help determine demand for services, which in turn will help predict a target date for mass production of components. By 1996, the total European market for fiber optic products could reach more than $820 million, according to Frost & Sullivan.

U.S. IMPORTS AND EXPORTS OF COMMUNICATIONS EQUIPMENT

For the year 1991, U.S. imports of communications equipment totaled $7.9 billion, an increase of 1.6% over 1990. Exports of communications equipment increased 4.5% in 1991 to $8.3 billion, resulting in a trade surplus of $389 million (Table 2-9).

Leading exports were radar/radio navigational equipment at $2.4 billion and telephonic apparatus and parts at $1.5 billion.

The major imported products included telephonic apparatus and parts at $1.0 billion and TV transmission/reception apparatus at $1.2 billion.

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3 Computers and Industrial Electronics

Computers and industrial electronics comprise the largest segment of the U.S. electronics industry, constituting 31% of the market in 1991, according to EIA's *Electronic Market TRENDS*. The sector includes a wide range of products, from palm-top computers to materials handling equipment to CAT scanners. As such, no one trend can be identified. Instead, each market segment exhibits its own characteristics, based on end-users, competition within segments, international trade issues, regulatory issues, and technology.

COMPUTERS

The U.S. computer industry was hard hit by the 1991 recession, experiencing falling prices, low demand for equipment, and corporate downsizing in capital equipment spending and employment. Although 1992 will most likely be better in terms of economic conditions, a continuing price war and changes in demand patterns point toward a year of low growth—most likely around 5%, according to *Electronic Business* magazine. Within the industry, the personal computer and workstation segments will fare better than mainframes and mid-range computers.

The entire computer industry may experience a great deal of structural change throughout the next decade as revenue from hardware decreases. The *U.S. Industrial Outlook '92* reports that, by 1996, U.S. computer firms will receive about 50% of their worldwide revenue from systems design and integration, software, and after-sales services. Sales will come from international, rather than from U.S. markets, and the expanding European market could become a focal point for both U.S. and Japanese suppliers.

Factory Shipments of Computer & Peripheral Equipment, Industrial Electronics, and Electromedical Equipment ($ Millions); United States, 1982-1991

TABLE 3-1

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Computer and Peripheral Equipment										
Computers and Parts	16,035.8	17,864.9	24,401.4	25,615.6	26,019.7	28,975.0	28,693.1	28,464.3	27,559.0	27,091.1
Computer Peripheral Equipment	18,728.4	20,843.8	23,953.6	23,828.0	22,194.9	23,865.0	25,442.9	25,729.3	25,708.5	25,290.8
Industrial Electronics										
Control and Processing Equipment	7,363.0	7,428.3	8,682.7	8,719.0	8,924.2	9,192.6	9,860.8	11,991.9	12,470.6	12,104.9
Testing and Measuring Equipment	4,695.0	5,200.4	6,279.1	6,007.9	5,735.8	6,008.7	5,806.5	5,953.1	5,954.5	5,768.3
Nuclear Electronics	546.1	489.5	479.7	518.6	559.6	600.7	615.9	606.0	650.8	630.5
Robots, Accessories, and Components	na	na	281.2	345.2	346.0	284.4	228.7	256.0	275.0	294.3
Other Electronic Systems & Equipment	3,869.0	3,412.4	4,665.0	4,530.1	4,720.4	5,238.3	5,587.9	5,991.5	5,608.7	5,538.5
Electromedical Equipment										
Diagnostic, Therapeutic, Monitoring and Support Equipment	3,060.1	3,301.1	3,390.5	3,352.3	3,324.8	4,004.5	4,596.2	4,594.2	5,147.9	5,533.6
Irradiation Equipment	1,342.0	1,543.6	1,757.6	1,675.4	1,606.3	1,571.1	1,418.7	1,745.2	1,861.6	2,001.1
TOTAL	55,639.4r	60,084.0r	73,890.7r	74,592.2r	73,431.7r	79,740.2r	82,250.7r	85,331.4	85,236.7	84,253.1

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available
SOURCE: U.S. Department of Commerce.

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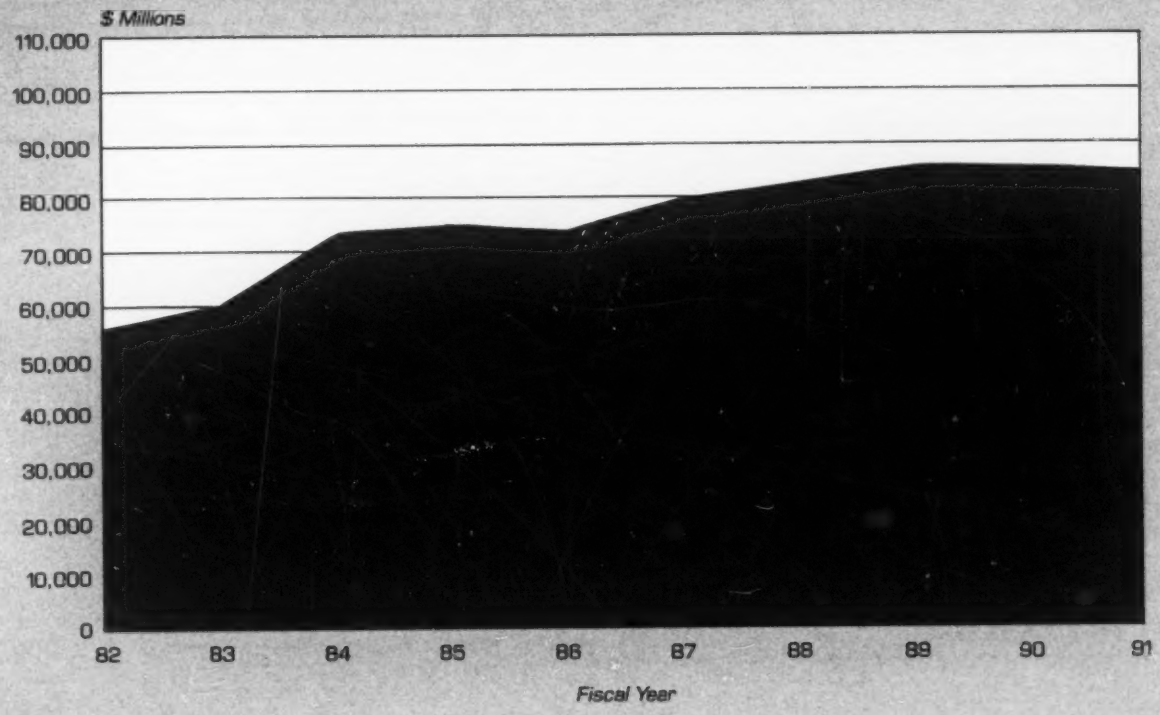
U.S. Factory Shipments of Computer & Peripheral Equipment, Industrial Electronics, Electromedical Equipment, and Other Electronic Equipment, 1982-1991

FIGURE 3-A



SOURCE: U.S. Dept. of Commerce, for further breakout see Table 3-1.

Personal Computers

The personal computer (PC) market, although fairly healthy, is a maturing market in a period of transition. In 1991, slow demand and intensive price cuts reduced profits for the approximately 50 major U.S. and foreign vendors, while alliances among vendors may have signalled a series of realignments within the U.S. PC industry. The 1991 agreement between Apple and IBM and the formation of the Advanced Computing Environment (ACE) consortium were two significant alliances in 1991 that will greatly impact the next generation of PC equipment.

To cope with the maturing market, vendors are turning toward software applications and the replacement market to generate sales. According to the *U.S. Industrial Outlook '92*, 1991 shipments of personal computers to the U.S. market surpassed 10.8 million units, an increase of only 3% over 1990. Broad-ranging price cuts caused the value of the U.S. market to rise only 2%, to approximately $31.5 billion. The outlook for the next five years is somewhat better. *Computer Industry Forecasts* predicts a 9.3% annual rate of growth from 1992 through 1995, with U.S. sales moving from $38 billion in 1992, to $49.6 billion in 1995 (Figure 3-B).

The largest segment of the personal computer market continues to be business/professional users, accounting for more than two-thirds of the total market. According to Data Analysis Group, businesses will account for 70% of PC shipments in 1992, followed by science/technology users, at 15%; educational users, at 10%; and other users, at 5%.

Desktop Computers

The personal computer market is generally segmented into desktop computers and portable computers. Although desktops have traditionally held the lion's share of the market, portables are expected to take about 26% of the market away from desktops by 1994. According to Dataquest, Inc., desktops will hold only 63% of the global computer market in 1994, compared to 89.3% in 1989. Another market research firm, InfoCorp, predicts worldwide sales of desktop computers will grow an average of 12.4% annually from 1992 to 1995, moving from 19 million units to 27 million units.

A continuing battle over operating systems and standards characterizes the competitive desktop market. Although the market is now dominated by computers using the DOS environment, the Windows operating environment, which provides a user interface similar to that of Macintosh, will dominate by 1995, according to Gartner Group. However, others disagree, predicting that Windows will run more on DOS than on other leading operating systems such as OS/2. Meanwhile, vendors have been allying themselves around competing technologies. The formation of the Advanced Computing Environ-

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ment (ACE) consortium is one such alliance and will most likely result in new products on the market by 1993.

Portable Computers

Portables—laptop, notebook, transportable, and handheld computers—are one of the few bright spots in the computer market. Data Analysis Group forecasts an average annual growth rate of 27.5% from 1992 through 1995, moving from $4 billion in sales in 1992 to $8.3 billion in 1995. Arthur D. Little forecasts are even more optimistic, predicting $6 billion in 1992 and $52 billion in the year 2000.

Right now, the moving force in the market is notebook computers, which are smaller, lighter versions of laptops. Supply problems experienced in 1990 have ended and dramatic drops in prices led to a surge in demand that brought about 50% annual growth in sales last year, according to some estimates. However, the current fast growth in the notebook segment could lead to an industry shakeout. An increasing number of vendors and models (200 different models by year-end 1991, according to supplier estimates), combined with fast price erosion and a short product cycle averaging about 18 months, could eventually push those companies without R&D capabilities completely out of the market.

Workstations

Workstations, which are single-user systems that compete with high-end personal computers and low-end mini-supercomputers, continued to expand their market niche in 1991. Traditionally based in the scientific and engineering communities, workstations are becoming more popular in the commercial arena. Their high speed and memory, combined with sophisticated software capable of multi-tasking and networking, have made them prime candidates for the electronic publishing, business graphics, financial services, and office automation markets. These capabilities have also made workstations one of the few segments of the computer industry to experience double-digit sales growth in 1991. *U.S. Industrial Outlook '92* reports a 25-30% increase in shipment value, to more than $9 billion, for the U.S. workstation market in 1991. For 1992, *U.S. Industrial Outlook '92* predicts a 28% increase, to approximately $12 billion, with unit volume forecast at 700,000 units. *Computer Industry Forecasts* expects the high growth to continue over the long run, predicting 19% average annual growth from 1992 through 1995 (Figure 3-B).

Mid-Range Computers

Unlike PCs and workstations, mid-range computers are multi-user systems, ranging from small systems serving less than 25 users to very large systems that can serve up to 1,000 users simultaneously. They are used by the service sector, durable goods manufacturers, government agencies, and educational facilities. Sales of this type of computer reached $26 billion in 1991, realizing 10% growth over the previous year.

Mainframes

Mainframe computers, ranging in price from less than $1 million to more than $15 million, process data for such large-volume functions as payroll, accounting, and order entry. Leading users, according to Computer Intelligence market research firm, are manufacturing industries, the medical profession, educational institutions, and the U.S. government.

Factory Shipments of Computers ($ Millions); United States, 1982-1991

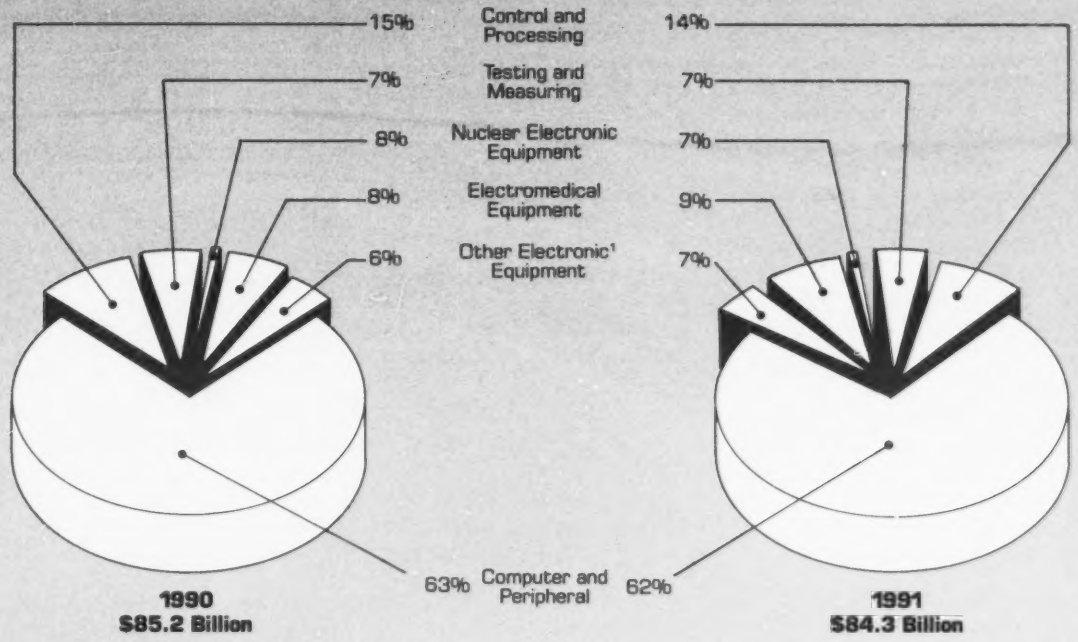
TABLE 3-2

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
General-Purpose Computers:										
Digital										
Less than $500			243.7	279.7	195.6	343.8	261.8	177.4		
$500 to $999			739.9	659.4	274.8	514.6	334.3	186.0	2670.5	2625.2
$1,000 to $2,499			3,577.2	2,239.8	1,910.0	2,204.3	2,399.7	2,331.3	2,059.0	2,024.0
$2,500 to $4,999			545.6	2,359.6	3,376.1	4,822.2	5,045.9	5,501.8	3,374.4	3,317.2
$5,000 to $14,999	10,482.7	11,588.5	1,079.0	1,506.2	1,223.8	1,502.7	2,750.7	4,759.5	4,895.5	4,812.4
$15,000 to $49,999			2,690.0	2,513.4	2,894.5	3,114.6	3,996.3	2,102.3	2,207.5	2,170.0
$50,000 to $249,999			4,258.6	2,906.8	2,715.8	2,715.7	2,402.2	3,339.9	3,134.7	3,081.5
$250,000 to $1 Million			1,127.3	2,469.1	2,995.2	2,905.7	654.6	724.8	845.2	830.9
Over $1 Million			1,037.3	1,613.5	1,716.2	1,987.6	2,714.6	2,840.3	2,950.6	2,900.5
Analog and Hybrid	87.3	83.9	21.3	19.8	14.8	34.4	41.3	12.1	8.2	8.0
Special-Purpose Computers:										
Digital	637.0	846.2	1,517.2	2,429.7	2,085.6	2,322.5	2,343.7	2,991.2	2,493.0	2,450.7
Analog and Hybrid	148.6	183.6	226.3	295.4	623.1	744.6	842.3	110.3	136.9	134.6
Parts for Computers	3,201.0	3,585.5	5,468.9	4,508.7	4,810.3	4,565.1	4,339.0	2,854.3	2,401.0	2,360.3
Automated word processors	1,479.2	1,577.2	1,869.1	1,814.5	1,183..9	1,197.2	566.7	533.1	382.5	376.0
Electronic calculators	na	na	na	na	na	na	na	na	na	na
TOTAL	16,035.8r	17,864.9r	24,401.4r	25,615.6r	26,019.7r	28,975.0r	28,693.1r	28,464.3	27,559.0	27,091.1

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not Available.
SOURCE: U.S. Department of Commerce.

Distribution of Factory Sales of Computer & Peripheral Equipment, Industrial Electronics, Electromedical Equipment, and Other Electronic Equipment, 1990-1991 (%)

FIGURE 3-B



SOURCE: Table 3-1.
[1]Includes Robots, Accessories, and Components.

The worldwide market for mainframes is declining as demand grows for the less expensive, but increasingly powerful, personal computers and mid-range computers. *Datamation* magazine reports only 2% average annual growth from 1984 through 1990. Some industry research firms concur, predicting -3% growth in the U.S. market, from $3.8 billion in 1991 to $3.6 billion in 1992.

Supercomputers

Moving up the scale from mainframes in today's computing environment are several versions of supercomputers: mini-supercomputers, which fall in the same price range as mainframes; huge scientific supercomputers, selling in the $10-15 million range; and massively parallel computers, which use hundreds or thousands of low-powered processors rather than the few high-powered processors of traditional supercomputers. Although parallel computers are considered technologically superior, complex programming requirements still leave room for growth in the other segments. However, as supercomputers evolve, distinctions in price and performance for the supercomputers and mini-supercomputers are becoming less noticeable.

Forecasters expect relatively slow growth in the market for supercomputers. According to Data Analysis Group, average annual growth from 1992 through 1995 will be 8.1%, with most of that growth coming from parallel supercomputers. Others agree that parallel computers will lead the market. *Computerworld* reports 31.1% average annual growth from 1990 through 1994 for massively parallel processing computers, with the market reaching $590 million in 1994, while *Computer Industry Forecasts* predicts 38.7% average annual growth from 1991 through 1994.

PERIPHERAL EQUIPMENT

Storage Equipment

Overproduction and a slow economy adversely affected the computer storage market in 1991. U.S. shipments of hard disk drives dropped 1.4%, according to Dataquest, while shipments of 5.25-inch and 3.5-inch floppy disk drives dropped 4%. Sales of 2.5-inch drives, however, kept in step with the growing notebook market to reach 520,000 units in 1991, from only 171,000 units in 1990. Sales in Europe and Japan were similar to those of the U.S. market; however, Dataquest expects better growth prospects in the Pacific Rim and South America.

Manufacturers of magnetic tape drives and storage devices are enjoying the benefits of a trend toward more archival storage. According to Freeman Associates, worldwide shipments of digital audio tape (DAT) storage libraries will jump to 5,200 units in 1995, from minimal shipments last year.

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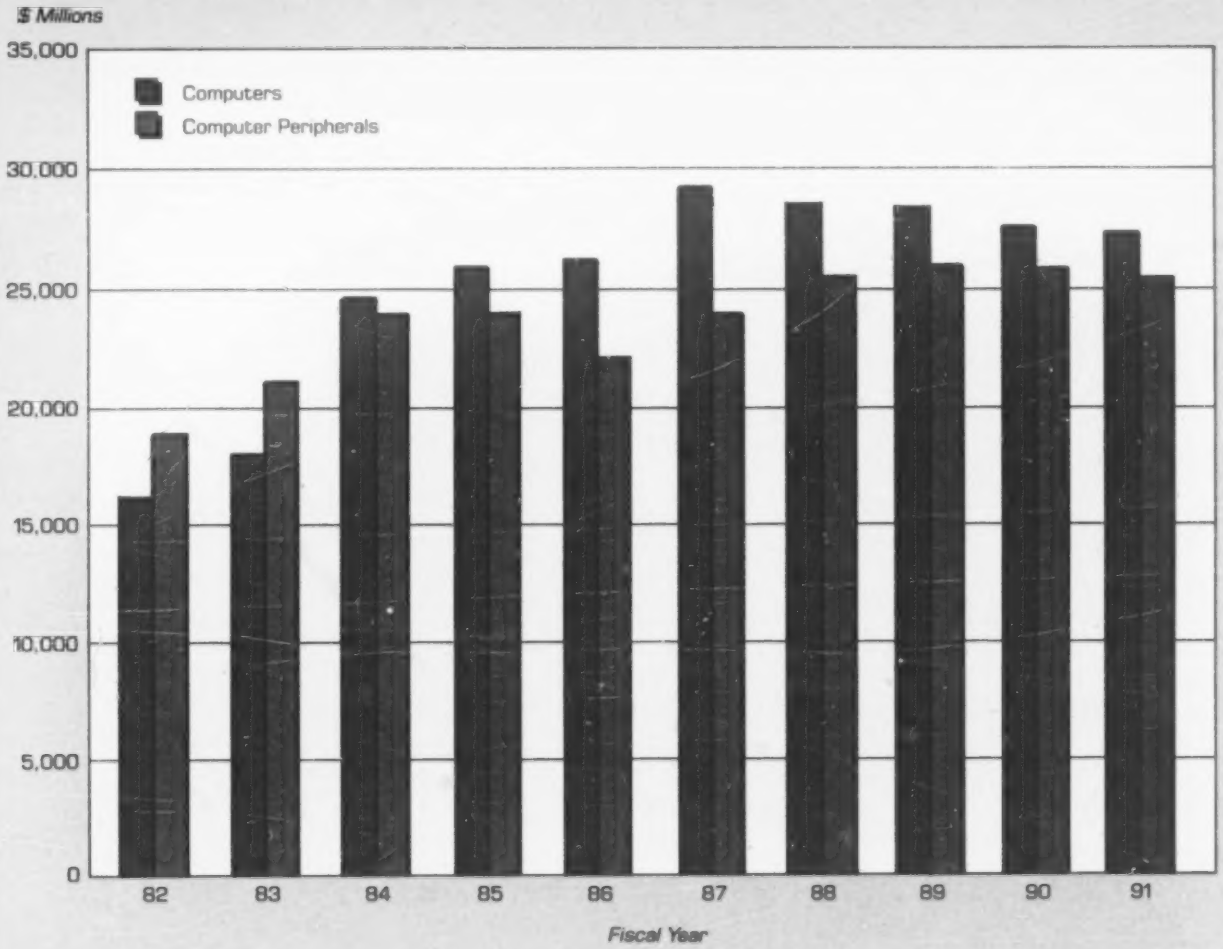
U.S. Factory Shipments of Computers and Peripheral Equipment, 1982-1991

FIGURE 3-C



SOURCE: U.S. Dept. of Commerce.

Optical Disk Technology

The word "optical" has caught the imagination of almost everyone in the electronics industry. The technology that produces consumer audio and video discs is present in the huge storage capabilities of CD-ROM, CD-I (Interactive) and DVI (Digital Video Interactive) applications. *Computerworld* magazine observed that "just as we were getting used to such basic computing components as transistors, very large-scale integrated circuits (VLSICs) and gallium arsenide semiconductors, we may soon find ourselves speaking of diffraction gratings, holograms and polarizers, as well as transphasors, a sort of optical transistor with potential switching speeds measured in trillionths of a second."

Evolving applications in educational environments, libraries, and even home entertainment are causing steady growth in the optical market. Disk/Trend estimates the 1991 U.S. market at $885 million while Frost & Sullivan forecasts growth to reach $4.8 billion by 1993. Within the market, CD-ROM drives are growing especially fast and can even be found in retail channels in electronic superstores. Freeman Associates forecasts a $236 million worldwide market in 1995, up from $167 million worldwide last year.

Computer Terminals

Computer terminals are classified according to their capabilities. Low-end "dumb" terminals are basic input/output hardware devices; "smart" terminals, or editing terminals, are preprogrammed by vendors to include additional features not found on dumb terminals; and intelligent terminals are user-programmable. Although many dumb terminals have added features that approach smart terminals in capability, it is the editing features and block transmission that distinguish the two segments. However, as manufacturers upgrade the fea-

Factory Shipments of Computer Peripheral Equipment (S Millions); United States, 1982-1991

TABLE 3-3

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Auxiliary Storage Equipment:										
Direct Access Storage:										
Rigid Magnetic Disk Drives	3,727.0	3,994.5	4,401.2	4,630.1	4,532.1	4,349.5	5,362.6	4,816.9	4,590.2	4,512.3
Flexible Magnetic Disk Drives			697.1	527.3	415.2	330.8	224.9	375.2	406.3	399.4
Optical Disk Drives[1]	na	na	na	na	na	130.7	116.8	196.1	186.0	182.8
Other	339.7	323.3	325.4	336.7	423.8	675.2	482.9	345.8	329.9	324.3
Serial Access Storage (Magnetic Tape Drives)	812.4	772.3	890.9	1,111.4	878.8	846.7	1,381.3	1,481.4	1,726.1	1,696.8
Magnetic Storage Media:										
Disks:										
Rigid	738.7	1053.7	1017.2	821.7	653.6	650.0	585.7	699.0	624.8	620.3
Flexible (incl. optical)	458.3	690.2	561.5	454.0	418.4	454.6	458.3	612.3	698.6	693.5
Computer Tape, Cassette, Cartridge, and Other Magnetic Tape	80.4	203.9	251.3	394.9	633.5	552.2	712.6	631.6	599.3	595.0
Input/Output Equipment:										
Keyboards	103.4	102.5	80.3	89.6	na	398.8	381.3	451.0	408.3	401.3
Other Keying Equipment	20.2	22.2	24.9	14.6	21.1	14.3	6.8	95.6	82.9	81.5
Media to Media Data Conversion Equipment:										
Output to Microfilm Recording Units	78.4	101.7	135.0	na	na	na	175.3	150.1	142.0	139.6
Tapeprint Units										
Card Tape Conversion										
Document Entry Conversion:										
Optical Scanning Devices	119.3	195.4	253.3	253.4	302.7	383.6	504.4	745.1	839.6	825.4
Voice Recognition Devices	na	na	na	na	na	19.6	54.2	40.8	21.4	21.0
Radio Frequency Devices	na	na	na	na	na	na	na	13.7	20.0	19.6
Magnetic Ink Devices	136.1	91.5	78.8	59.8	44.4	65.9	124.8	95.5	91.3	89.8
Magnetic Stripe	na	na	na	na	na	na	na	30.8	36.3	35.7
Other	na	na	na	na	na	na	na			
Printers:										
Serial type	1,633.6	1,921.6	1,668.9	1,790.9	1,992.9	2,556.2	2,404.0	2,568.2	2,075.2	2,039.9
Line type			675.6	650.9	724.5	540.7	800.1	499.8	379.3	372.9
Page type						226.8	457.8	634.3	952.7	936.5
Plotters	247.5	232.2	240.8	466.1	564.9	532.7	574.4	672.4	633.2	622.5
Graphic Displays	184.6	188.4	192.7	166.2	145.8	149.2	243.2	150.4	84.1	82.7
Other input/output devices	652.9	606.1	1092.2	1156.4	717.0	1,159.0	1,052.6	868.9	816.4	802.5
Terminals:										
General Purpose:										
Single CRT:										
Monochrome	2,137.8	2,079.9	1,984.6	638.0	532.5	316.0	356.2	282.2	236.5	232.5
Color				413.7	231.9	138.1	106.7	67.0	115.4	113.5
Teleprinters	496.4	449.7	369.3	170.4	496.0	319.9	305.5	303.4	265.8	261.3
Multistation CRT/Teleprinter	109.0	122.9	72.1	43.6	135.9	116.4	63.9	98.2	103.6	101.8
Other	397.5	685.5	799.2	814.6	823.8	564.8	990.5	1,398.4	1,459.9	1,435.1
Special Purpose:										
Graphic	454.5	770.1	952.0	887.3	609.6	508.0	594.0	509.3	414.7	407.7
Other	252.1	248.4	241.7	242.7	436.1	466.1	255.8	100.7	61.8	60.7
Funds Transfer	na	na	na	306.9	287.7	287.6	287.1	290.1	234.5	230.6
Point-of-sale (POS)	na	na	na	413.6	475.9	496.8	404.0	708.9	722.4	710.1
Communications Interface Equipment:										
Carrier equipment	189.8	324.0	330.3	131.7	*	*	*	*	*	*
Modems:										
Up to 2000 baud setting	37.1	70.2	71.2	108.3	*	*	*	*	*	*
2001 to 4800 b/s	61.7	160.6	101.9	88.8	*	*	*	*	*	*
Over 4800 b/s	42.8	17.2	95.6	88.9	*	*	*	*	*	*
Digital Multiplexors	388.6	437.5	491.8	523.8	*	*	*	*	*	*
Other Peripheral Equipment	1,041.9	1,044.9	1,333.5	1,632.8	1,610.0	1,450.2	633.5	1,254.5	1,397.9	1,374.2
Parts for Peripheral Equipment	3,806.6	3,933.4	4,523.3	4,618.9	4,086.8	5,153.6	5,561.7	4,541.9	4,952.1	4,868.0
TOTAL	18,728.4	20,843.8	23,953.6	23,828.0	22,194.9	23,865.0	25,442.9	25,729.3	25,708.5	25,290.8

r-Revised.
e-Estimated.
na-Not available.
*Included in Table 2-4.
SOURCE: U.S. Department of Commerce.

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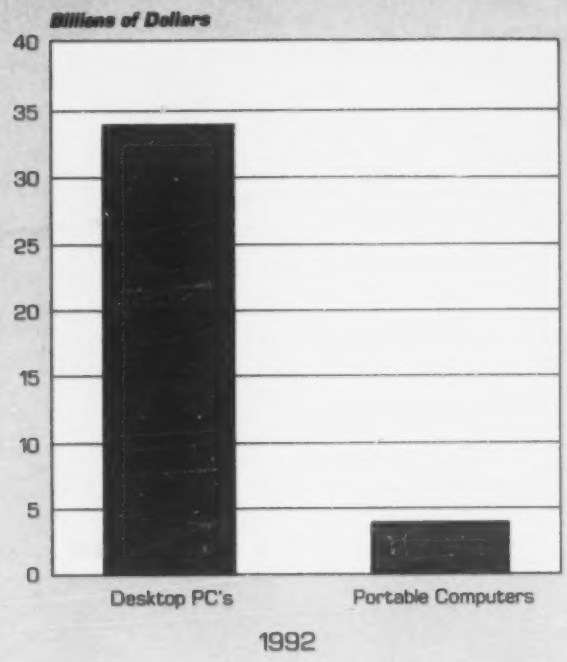
1992 Forecast of U.S. Sales of Personal Computers FIGURE 3-D



SOURCE: Computer Industry Forecasts

tures of dumb terminals, the two categories are merging into one.

The X Windows terminal market, which offers users a graphical interface, is expecting tremendous growth in the next few years. According to X Business Group Inc., worldwide shipments of X Windows Terminals could grow in value from $343.5 million in 1991 to $1 billion in 1993. International Data Corporation agrees, forecasting an installed base of 1.8 million units by 1995.

Printers

An increase in desktop publishing plus a drop in printer prices have increased growth in the market for non-impact printers, which includes inkjet, thermal, and, primarily, laser printers. According to *U.S. Industrial Outlook '92*, U.S. sales of non-impact printers grew 10% in 1991, to almost $8 billion. The impact segment, meanwhile, dropped 10% to 5 million units shipped in 1991, according to Dataquest. However, impact printers continue to make up the bulk of installed printers, accounting for 74% of the installed base in the United States.

Computer Software

One of America's fastest growing high technology sectors, the computer software industry continually outperforms the GNP, surpassing it by 3.8% in 1991. According to IDC, the U.S. packaged software market grew 13.4% in 1991, to $20.3 billion. Revenue may appear to drop in 1992, however, due to draft rules proposed by the American Institute of Certified Public Accountants, which may change how software firms are required to record revenue.

Application programs are already causing significant growth in the industry and sales from the widespread application of multimedia could grow even more in years to come. The Information Workstation Group forecasts a $10.3 billion business for multimedia products in 1994, excluding the consumer segment. The forecast for multimedia is divided into business presentation ($4.4 billion), information retrieval ($3.4 billion) and education/training ($2.5 billion). With the ability to handle massive data volumes, the incorporation of video (with its massive band-width requirements) has become a reality — particularly with video signal compression techniques.

ARTIFICIAL INTELLIGENCE

The term "artificial intelligence" (AI) sometimes conjures images of all-knowing, talking computers (such as Joshua in the movie "War Games"). In reality, currently available artificial intelligence systems are application-specific, focusing on single tasks such as pattern recognition or image stabilization. One such example is the expert systems used by American troops in the Persian Gulf War last year. The Pulse Radar Intelligent Diagnostic Environment (PRIDE) was used solely to trouble-shoot problems with the radar of the Hawk air defense missile system, while the Single Army Battlefield Requirements Evaluator (SABRE) helped commanders position forces in the field.

Intelligent Software Strategies reports a growing market for expert systems, based on the development tools and consulting services related to the industry. In 1991, sales of expert systems development tools increased 16% to more than $140 million, while consulting services totaled $96 million.

Neural networks, another type of artificial intelligence, also constitute a growing market. According to *U.S. Industrial Outlook '92*, the 1991 U.S. market for neural networks surpassed $100 million and the number of companies in the business more than doubled, from 65 in 1990 to 135 in 1991. Neural networks are AI systems that use interconnected processing elements to mimic human reasoning and learning capabilities. They are used in such fields as chemical processing, robotics, medical diagnoses, and finance.

Still another AI process, fuzzy logic, is moving into mainstream use. Unlike traditional computer systems, which require precise mathematical formulas to operate, fuzzy logic systems can respond to imprecise or variable conditions. Fuzzy logic controls, which are already widely used in Japan, are now being embraced by the U.S. market as well. Consumer electronics manufacturers currently use fuzzy logic in camcorders to stabilize images and in some televisions to vary picture brightness in response to external lighting conditions. Industrial manufacturers are investigating fuzzy logic controls for use in industry control systems, while government agencies, such as NASA and the National Institutes of Health, are examining fuzzy logic for use in medical diagnoses and docking space shuttles.

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Factory Shipments of Control and Processing Equipment ($ Millions); United States, 1982-1991

TABLE 3-4

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Controls										
A.C. full voltage starters, contactors, reduced voltage controls, 1000 volts or less	372.2	325.9	349.7	313.7	386.4	400.8	383.1	556.8	573.3	557.9
Motor control centers, 1000 volts or less	214.9	242.2	250.5	282.2	261.8	243.1	251.9	337.0	354.9	345.4
Starters and contactors for squirrel cage and wound rotor and synchronous motors, over 1000 volts, air break and oil immersed	66.0	80.7	47.4	49.6	49.9	44.2	52.2	129.5	117.6	114.5
Pilot circuit devices, such as limit switches, interval timers, photoelectric devices:	213.8	200.3	305.7	271.3	323.7	362.6	424.5	418.8	403.3	392.4
Other general industry devices: Pushbuttons, Rheostats and Resistors, Brakes, Synchronous Motor starters	242.7	266.8	319.1	282.0	301.1	305.0	340.7	375.9	356.4	346.8
Marine and Navy auxiliary controls and accessories	173.3	189.1	160.9	161.3	179.4	175.9	204.9	228.4	234.3	228.0
Metal mill										
Crane and hoist controls	29.4	20.1	28.3	26.9	20.3	25.7	37.0	37.5	44.8	43.6
Adjustable speed drives	270.4	245.6	320.8	353.1	381.9	440.9	522.5	616.5	670.4	652.4
Numerical controls	554.3	599.0	910.0	843.6	815.6	741.3	802.6	821.5	922.1	897.3
Other controls and Parts	1,046.0r	1,411.8r	1,602.1r	1,522.3r	1,533.5r	1,684.3r	1,735.3r	1,919.8	1,872.6	1,822.3
Processing										
Temperature	118.7	97.0	131.0	137.8	128.6	181.0	175.0	575.2	559.5	542.0
Pressure, draft and vacuum	141.2	128.4	154.9	168.5	168.5	185.2	204.3	386.2	414.9	401.9
Flow and liquid level	547.7	508.3	585.1	623.9	593.8	628.5	694.3	803.5	891.3	863.4
Humidity instruments	16.6	16.2	18.9	19.1	18.5	24.4	29.0	21.1	24.9	24.1
Continuous process gas and liquid analysis instruments	218.9	220.5	229.7	273.2	233.1	238.3	276.2	327.2	341.3	330.6
Instruments for other variables (speed, viscosity, position, density, specific gravity, sequence, etc.), includes mechanical types	95.6	84.3	91.7	116.5	98.5	92.7	115.9	113.2	120.2	116.4
Industrial process display and control instruments (operate from standard transmitted signals excl. aux. sta.)										
Electronic systems (unified architecture type):										
Controllers	131.4	145.4	109.4	92.0	104.6	105.7	126.6	153.4	166.8	161.6
Recorders	72.5	65.6	75.6	76.9	71.3	91.7	74.4	76.0	80.3	77.8
Indicators	32.8	32.6	26.9	40.7	35.1	36.7	41.6	43.2	44.1	42.7
Electronic systems (non-unified architecture type)	519.1	440.9	651.7	705.6	690.1	778.2	860.3	1,038.9	1,118.2	1,083.2
Multi-function process computers	175.3	171.2	143.6	135.4	154.0	177.9	177.9	181.6	188.1	182.2
Pneumatic systems (excl. aux. station)	62.7	78.5	62.3	66.3	60.7	59.5	64.4	57.1	52.3	50.7
Annunciators	33.3	13.3	20.5	36.7	38.5	22.3	25.8	26.2	19.9	19.3
Physical properties testing and inspection equipment	371.4	365.1	394.7	408.8	493.5	533.9	547.0	77.1	799.6	774.6
Kinematic test and measuring equipment	140.6	128.8	164.0	112.5	130.3	148.9	148.9	177.4	168.9	163.6
Automatic regulating devices	495.3	504.8	507.6	622.4	608.6	514.7	605.7	897.4	984.0	953.2
Other process instruments	509.9	409.5	579.4	621.6	791.5	727.2	680.7	587.1	613.0	593.8
Parts of process instruments	497.0	436.3	441.2	355.2	251.4	222.0	258.2	308.4	333.5	323.1
TOTAL	7,363.0r	7,428.3r	8,682.7r	8,719.0r	8,924.2r	9,192.6r	9,860.8r	11,991.9	12,470.6	12,104.9

r-Revised. e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

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INDUSTRIAL AUTOMATION

Industrial automation refers to the use of programmable machines for enhancing productivity in discrete manufacturing processes. There are five major types of automation equipment manufactured in the U.S.: programmable controllers, software-based process control systems, loggers and recorders, sensors and activators, and data acquisition equipment. Machine tools, robots, and automated guided vehicles are examples of familiar industrial automation hardware.

Some experts expect U.S. vendors to lose market share when the industrial automation product is primarily hardware-related. Vendors from the Far East are expected to continue to develop cost and manufacturing superiority in these hardware areas.

Industrial Controls

U.S. factory shipments of control and processing equipment were $12.1 billion in 1991, down 3.3% from the 1990 level of $12.5 billion (Table 3-4).

Industrial controls are used for starting, speed-regulating, stopping, and protecting electric motors. Some controls have specific applications, such as metal mill controls, crane and hoist controls, and machine tool controls. Demand for industrial controls varies with levels of investment in new plant and equipment. Programmable controllers are finding many new applications in the process industry because they offer functions such as advanced control algorithms. They are used in a number of industries including communications networks and manufacturing quality control.

The two leading process and control instruments continue to be numerical controls and testing/inspection equipment. The growth in numerical controls is due to the development of integrated computer numerical controls, which enable users to control and synchronize a variety of machines, and to link these machines to a central computer. Computer numerical controls are the largest segment of the numerical control industry, constituting 59% of the total value shipped in 1991.

As with other segments of the electronics industry, the industrial controls area is moving towards interconnected systems. Some analysts predict the development of industrial "nervous systems," which will use sensors to supply information to expert systems that, in turn, will provide feedback to other controls. According to *High Technology Business*, Japan's push for automation has proved a fertile market for U.S. sensor makers. Sensors are a vital component of an interconnected manufacturing system. Japanese manufacturers routinely include pressure sensors in computer-controlled machine tools, hydraulic robot limbs, vacuum-assisted picking tools, and other automated hardware.

Electronic Temperature Controls

Electronic temperature indicators can be divided into two groups: contact and non-contact instruments. Contact-type instruments use thermo-couples, RTds, thermistors, or similar sensors, while non-contact instruments use infrared and optical radiation pyrometers. Although non-contact thermometers are sometimes more convenient and provide higher temperature ranges, they are more expensive and generally less accurate than contact thermometers.

Revenue in the world market for electronic temperature controls is expected to increase moderately through 1997, coming from increased unit movement rather than from price increases. According to Market Intelligence Research Corporation, revenues will reach $2.1 billion in 1997, compared to $1.2 billion in 1987.

Trends affecting the market include an increase in the use of smart technology and a move towards integrated systems. Smart technology refers to temperature sensors that use microprocessors, rather than electro-mechanical devices, to process data. The instruments are comprising an increasingly larger segment of the market and promise to grab larger shares as they begin to use new technologies incorporating artificial intelligence, fiber optics, and multi-function units.

Factory Shipments of Numerical Controls ($ Millions); United States, 1982-1991

TABLE 3-5

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Controls for numerically controlled machine tools:										
Positioning type	14.0	14.4	18.7	16.4	19.5	20.3	19.2	20.8	19.7	19.2
Continuous path type	139.1	105.5	154.1	147.9	125.3	101.8	90.4	90.8	124.7	121.4
Digital readout systems, including dial and plug board type	35.0	32.4	22.6	18.7	18.4	19.0	18.1	17.9	14.3	13.9
Programmable controllers (sold separately)	366.2	447.2	714.6	660.6	652.4	600.2	674.9	692.0	763.4	742.9
TOTAL	554.3	599.5	910.0	843.6	815.6	741.3	802.6	821.5	922.1	897.3

r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

The trend towards integrated systems has grown as end-users automate more and more plant operations. An industry protocol is in the process of being developed; once it is operational, the move towards integration will increase even more.

Robotics

The Robotics Industries Association reports that U.S. shipments of robotic equipment totaled $430 million in 1991. Orders totaled $490 million, but dropped for the first time in three years in 1991, losing 5% from 1990's $517 million. One bright spot in the market is international trade. *U.S. Industrial Outlook '92* states that U.S. exports of robots and parts totaled $210 million in 1991, a 27% increase over 1990, while imports of robots and parts were $300 million—$180 in complete robots and $128 million in parts.

The robotics market is not a profitable one. Most U.S. robotics firms operate at a loss during much of their existence

Factory Shipments of Robots, Accessories, and Components ($ Millions); United States, 1984-1991 TABLE 3-6

	1984	1985	1986	1987	1988	1989	1990	1991e
Servo-Controlled Robots:								
Point-to-Point Type:								
Welding, soldering, brazing, and cutting	56.9	74.6	86.0	64.6	32.3	29.3	28.0	30.0
Foundry, forging, and heat treating	1.9	0.7	3.2	3.4	3.2	9.3	10.0	10.7
Inspection, measuring, gauging and sorting								
Plastics molding/forming	na	na	3.7					
Metal bending, shearing/forming								
Drilling/cutting	na	na						
Machine tool loading and unloading	4.1	3.8						
Assembly	20.9	17.8	19.1	19.6	8.0	8.1	9.0	9.6
Material handling and parts transfer N.E.C.	35.4	44.9	45.1	48.3	27.0	26.0	25.0	26.8
Other								
Continuous-Path Type:								
Welding, soldering, brazing, and cutting	16.6	22.4	13.8	9.0	3.7	2.2	2.0	2.1
Spraying, painting, gluing, and sealing	46.0	41.4	36.9	41.3	30.1	35.1	38.0	40.7
Other, including fettling, grinding, polishing and deburring	24.3	49.3	48.1	16.8	33.4	25.6	27.0	28.9
Non-Servo-Controlled Robots	16.2	18.0	15.7	8.2	17.1	14.9	15.0	16.1
Other Robots, Including Educational, Hobby, and Experimental	3.3	2.8	3.0	8.6	na	na	na	na
Robot Accessories, Subassemblies, Components and Parts Sold Separately:								
End-of-arm tooling	1.3	3.7	8.4	6.1	3.3	3.5	4.0	4.3
Vision, sonic, force, tactile and proximity sensors	15.2	17.7	14.8	15.6	18.2	20.5	22.0	23.5
Interface modules								
Compliance devices			1.7	0.8	1.3	2.0	3.0	3.2
Joint locating and guidance systems for welding	10.8	4.9	1.2	4.0	5.7	6.3	7.0	7.5
Guarding and safety devices			1.7					
Other accessories, etc.	28.3	43.2	43.6	38.1	45.4	73.2	85.0	91.0
TOTAL	281.2	345.2	346.0	284.4	228.7	256.0	275.0	294.3

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

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because robotics production combines low volume with high unit costs. In fact, a survey by the Department of Commerce's Office of Industrial Resource Administration shows only one profitable year, 1986, for the industry during the 1980s. The entire industry sells primarily to one market, the automobile industry, and is heavily dependent on the level of new investment from the U.S. manufacturing sector. To compensate, small U.S. firms entering the field often find it cost effective to import basic robots and add value by tailoring software and peripherals to the needs of their customers.

For the end-user, robotics can improve profitability. Some robotics applications have reportedly yielded productivity gains of as much as 20-30%, and such gains are expected to increase as new developments in robotics become commercially available. Some of the most significant potential gains could come when robots are integrated into manufacturing networks rather than being used as stand-alone single task units. A much broader set of tasks awaits the robot as technological advances resolve the complex problems of machine vision, sensing methods, communication, and mobility.

One small, but promising, segment of the robotics industry directly related to electronics is special non-contaminating robots for integrated circuit (IC) processing. With IC processing moving toward extreme cleanliness for submicron line widths, non-contaminating robots are beginning to take a defined place in the clean room.

Major industries using robots include home appliances, aerospace, consumer goods, and off-road vehicles. The number of industries should increase as the use of machine vision, tactile sensing, and mobility gives robots added capabilities. Indeed, the near future could find robots used more frequently in industries such as textiles, food processing, pharmaceuticals, furniture, construction, and health care.

Machine Vision

Machine vision systems combine the advantages of optics, advanced software, and robots, offering inspection and quality control capabilities that surpass all other methods. A typical system consists of a light source, a camera or cameras, and a computer that processes the images, supported by image-processing software. In use, the solid-state camera is focused on an illuminated area in which objects move at full manufacturing speed. The camera captures an image from light reflected by each object, and a sensor in the camera converts the incoming light into electrical signals. The signals are fed to the image-processing computer, which compares the information to pre-programmed parameters. If the data fall within these parameters, the process continues uninterrupted. If not, the computer notifies production personnel, or even another computer, that something is awry.

The genesis of the industry can be traced back several years to work in robotics and artificial intelligence at a number of academic institutions. Such research has led to the realization that machine vision, as a separate technical discipline, has much to offer industry.

Although machine vision manufacturers initially concentrated on sales in the automotive industry, they are diversifying into other manufacturing segments, including electronics, quality control, defense weaponry, aircraft, and food processing markets. In the electronics industry, high-end, stand-alone vision systems are playing an important role in speeding up the inspection of such components as multi-layer printed circuit boards. Software applications for vision systems have expanded to include pattern recognition algorithms that can determine an object's presence or absence, identify the object's orientation, locate circles and their centers, and find the edges of objects. These advanced functions allow manufacturers to improve manufacturing capability by matching high-speed production rates with high-speed inspection rates.

Specialized machine vision systems, such as automated optical inspection (AOI) systems, are required for such complex inspection tasks as detecting errors in multi-layer printed circuit boards. These systems may cost as much as half a million dollars, but have paid customers back with a critical edge over non-automated competitors. Indeed, many companies view vision systems as required components for electronics assembly and inspection, especially in those cases where product inspection has become impossible for humans to perform.

Materials Handling

Increasingly sophisticated ways of handling materials are revolutionizing the manufacturing process. With the increasing use of robots, conveyors, automated stockrooms, and techniques such as bar coding, industry has begun to see dramatic gains in productivity and efficiency from more precise inventory control, production, shipping, and materials handling management. A leading manufacturer estimates that computerized materials handling sales will increase from $5 billion in 1985 to approximately $15 billion in 1995.

Bar coding and other factory data collection methods are fast-growing segments of the materials handling industry. Market Intelligence Research Corporation forecasts the factory data collection equipment market to grow at an average annual rate of 30%, reaching $1.8 billion by 1997. The research firm predicts terminals will continue to hold the largest share of the market, but will lose ground to radio frequency identification, magnetic strip identification, and vision equipment.

Meanwhile, the electronics industry has displaced the automotive industry as the largest manufacturing-sector consumer of bar code products and services. According to Venture Development Corporation, all manufacturing industries combined account for 40% of bar code purchases, while service industries account for 51%. The leading application for bar codes is inventory control, followed by point-of-sale, and production control, which includes process control, quality control, and shop floor control.

CAD/CAM/CAE, CIM

Computer-aided design (CAD) and computer-aided manufacturing (CAM) systems help engineers rapidly design mechanical parts, analyze the parts to close tolerances, and directly generate machining instructions. Computer-aided engineering (CAE) extends the one-dimensional on-screen design developed by CAD to the engineering behavior of the product, while CAM does the same for manufacturing, by quantifying precise manufacturing standards. Thus, by avoiding time-consuming and expensive manual drawing and prototype work on the shop floor, companies can significantly reduce the time and cost of developing new products. New industrial applications are also being developed that will assist engineers in

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special programs for structural, thermal, and circuit analysis. New programs will allow verification of such items as tool clearances, cutter paths, and fixtures.

Complexity of designs is not a problem for CAD/CAM, which may be used to draft and build both simple and complex parts ranging from hinges to robots. Engineers use CAD/CAM to design parts and machinery, generate electronic schematics, diagram complex microcircuits and printed circuit boards, calculate manufacturing specifications, list parts, and furnish bills of material. Not only do CAD/CAM systems increase productivity, they also shorten development cycles, reduce errors, and decrease labor requirements. In short, they help eliminate the high cost of preparing parts for manufacture.

The market for CAD/CAM/CAE has been increasing steadily. According to the research firm Daratech, revenue for the total market—including VARs, resellers, vendors, and developers—moved from $8.3 billion in 1989 to $11.3 billion in 1991, experiencing average annual growth of 16.7%. U.S. vendors are benefitting greatly from an expanding worldwide market. Since CAD/CAM is software driven and American manufacturers currently hold the technological upper hand in software development, U.S. producers enjoy a substantial competitive advantage over their overseas counterparts. By selling primarily to European nations and Japan, U.S. vendors maintained revenues of $7.3 billion in 1991, according to Daratech.

Computer-Integrated Manufacturing (CIM)—part of the trend toward interconnecting equipment, departments, companies, industries, and even the world—enhances the communications process of an entire business entity through feedback loops between the design (CAD), engineering (CAE), and manufacturing (CAM) areas, as well as through links to other functions of business, such as sales, material purchasing, robot controllers, etc. Data Analysis Group forecasts 7.5% average annual growth for the manufacturing automation market, moving it from $24.3 billion in 1992 to $30.2 billion in 1995.

TESTING, MEASURING AND ANALYZING EQUIPMENT

Electronic test and measurement instruments are used for measuring, testing, and analyzing a wide range of electrical and electronic variables such as current, resistance, capacitance, inductance, frequency, and waveform. U.S. factory shipments of electronic testing, measuring, and analyzing equipment are estimated at $5.8 billion for 1991, down from 1990 shipments of $5.9 billion (Table 3-7).

The instruments are employed extensively in manufacturing plant inspection stations; laboratories; research establishments; appliance, television, and radio repair shops; automobile garages; and other service industries. Test equipment is also used for control purposes to improve yields during the manufacture of discrete components. This includes use of devices to control "spiraling" resistors to a specific value, and instruments for winding capacitors to a predetermined capacitance.

Trends in the industries which use testing and measuring equipment have a strong impact on demand of electrical test and measurement instruments. The electronics industry uses automatic test equipment (ATE) to test semiconductors and printed circuit boards. Manufacturers are increasingly introducing specialized test equipment such as ATE for field-service use. Such equipment can greatly reduce test costs for a particular application, although the need for specialized design also limits adaptability for other uses.

Due to their low cost, manufacturing-defect analyzers (MDAs) are selling at a rapid pace. These limited capability in-circuit testers offer an alternative to the traditional board testing methods. In addition, the short production runs and complexity of application-specific integrated circuits are encouraging manufacturers to develop instruments that readily generate test programs from computerized design specifications.

Within the test and measurement industry, digital oscilloscopes are challenging analog scopes for general purpose uses. Sales of digital oscilloscopes have grown rapidly with the introduction of high-performance models priced competitively with analog models. Analog scope manufacturers, unable to meet the demand for high performance scopes, have experienced some erosion of their markets.

POWER SUPPLIES

The electronic power supply industry includes plug-in, linear, switches, uninterruptible, line conditioner, and high voltage power supplies. According to Micro-Tech Consultants, the U.S. power supply industry is expected to grow from $6.1 billion in 1989 to $7.6 billion in 1993, with switches increasing their share to more than 63% of the business.

Programmable power supplies, which bundle a power switching element with logic control circuitry, are a growing sector of the power supply market. Venture Development Corporation (VDC) predicts the U.S. market for programmable power supplies will grow to $288.5 million in 1995, from the current level of $179.3 million.

According to VDC, the U.S. market for the uninterruptible power supply (UPS) segment will grow at an even faster rate, from close to $1.1 billion in 1991 to at least $2 billion in 1993. The research firm expects substantial price decreases over the next few years to contribute to strong growth in unit shipments.

The service sector's response to irregularities in electrical power provided by utilities is another factor expected to contribute to growth. UPSs are being used more and more to minimize such problems because they are capable of maintaining total continuity of electric power to a critical load. To do so, UPSs isolate critical loads from the voltage fluctuations, frequency variations, and electrical noise associated with utility-supplied electric power during normal operation. If the utility-supplied electric power should fail, UPSs provide clean and stable electric power to the critical loads until an orderly shutdown is accomplished, auxiliary power sources are substituted, or utility-supplied electric power is restored.

Also contributing to the accelerating demand for UPS is the continuing rapid growth in many of those industries and service sectors generating UPS applications. Among those in-

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Factory Shipments of Testing and Measuring Equipment (S Millions); United States, 1982-1991 TABLE 3-7

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
A.C. watt-hour meters	142.9	179.3	181.1	197.1	186.1	183.0	157.4	175.6	174.5	169.0
Combined watt-hour and demand meters and time switch meters	69.6	74.8	85.4	94.4	103.2	101.4	118.6	123.5	122.1	118.2
Other integrating meters and instruments, and parts	126.5	103.9	151.9	111.1	113.6	116.0	111.6	102.3	93.9	91.0
Voltage, current and resistance measuring equipment	208.5	228.8	269.9	276.0	260.9	302.3	283.8	290.7	274.9	266.3
Multimeters	105.1	103.9	126.6	132.9	127.0	136.4	132.1	149.2	146.7	142.1
Power and energy measuring equipment	19.3	53.8	59.2	80.2	101.0	98.4	79.1	85.8	95.1	92.2
Frequency measuring	98.4	108.7	113.9	136.6	123.5	112.2	104.1	112.7	99.5	96.4
Waveform measuring and/or analyzing equipment	675.5	678.2	738.6	743.5	679.3	658.3	406.7	416.6	394.5	382.2
Signal generating equipment	278.6	327.8	351.2	315.3	324.7	356.8	279.0	296.8	294.5	285.3
Field strength and intensity measuring	128.9	155.4	211.4	248.8	231.3	na	na	na	na	na
Impedance and standing wave ratio measuring	49.7	35.9	54.4	43.7	49.0	48.2	48.8	43.4	40.2	38.9
X-Y plotters	167.5	182.6	263.4	34.1	33.7	19.3	15.9	7.9	5.2	5.1
Time measuring & counting equipment	31.5	na	na	na	na	na	na	na	na	na
Automatic testing and measuring equip.:										
Combination/Group testing sets	562.6	621.1	553.4	611.0	590.1	622.2	506.0	529.6	587.8	569.4
Component part test sets:										
Electron tube	256.4	2.5	2.3				1.4	1.3	1.1	1.1
Semiconductor		246.8	475.6	469.6	459.5	564.5	580.6	570.1	596.6	578.0
Other	69.0	115.6	201.2	182.6	236.0	459.3	533.5	508.8	474.6	459.8
Other	190.4	201.5	183.2	159.9	167.6	297.8	390.6	355.4	342.7	332.0
Standards and calibration	133.8	132.5	130.7	183.8	145.0	185.9	195.7	185.8	165.8	160.6
Microwave test	120.5	33.6	36.2	34.3	34.8	47.2	54.3	45.1	38.9	37.7
Communications testing (excl. microwave)	na	39.0	178.3	262.5	259.4	363.4	446.4	435.8	442.7	428.8
Internal combustion engine analyzers	220.9	232.3	306.6	311.6	296.1	273.6	280.8	272.8	342.5	331.8
Associated devices for testing and measuring	77.8	117.6	225.4	na	na	na	na	na	na	na
Other test, measuring and analyzing	961.6	1,224.8	1,379.2	1,378.9	1,214.0	1,062.5	1,080.1	1,244.1	1,220.7	1,182.5
TOTAL	4,695.0	5,200.4	6,279.1	6,007.9	5,735.8	6,008.7	5,806.5	5,953.1	5,954.5	5,768.3

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

dustries and service sectors are data processing, process controls, communications, utilities, military/aerospace, and medical laboratories.

The external power supply market is also rising, due partially to increased use in consumer products and medical equipment, says VDC. The U.S. market could grow at an average annual rate of 15.6% in coming years, reaching $475 million by 1995. Also helping the market is a trend towards miniaturization in the electronics industry. OEMs have been forced to use external power supplies because smaller products made the use of internal power supplies impractical.

NUCLEAR ELECTRONIC EQUIPMENT

Nuclear electronic instruments perform radiation detection, measuring, and control functions. The instruments are applied in nuclear reactor operations in radioisotope utilization, in industrial and food processing, and in the medical, scientific and educational fields. U.S. shipments of nuclear electronic equipment decreased to $630.5 million in 1991, from the 1990 level of $650.8 million (Table 3-8).

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Factory Shipments of Nuclear Radiation Detection and Monitoring Instruments (S Millions); United States, 1982-1991 TABLE 3-8

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Radiation detecting elements, including chambers, sold separately	46.6	39.0	38.4	35.7	36.8	65.3	66.9	88.0	97.1	94.1
Solid state detectors sold separately			14.2	16.9	19.9	19.5	21.7	35.2	29.1	28.2
Nuclear monitoring instruments, including environmental, personal dosimetry, and medical monitors, stationary and portable	103.9	93.7	126.6	120.6	125.9	126.4	111.7	169.2	173.9	168.5
Medical and biological counting systems for in vivo counting										
Sample and flow counting systems	28.7	29.5	34.7	36.0	33.1	30.7	35.1	28.6	30.1	29.2
Scalers sold separately	12.1	11.2	2.5	2.4	4.2	4.9	8.9	8.7	8.7	8.4
Special amplifiers for nuclear applications	5.7	6.1	7.1	5.2	4.2	4.0				
Pulse analyzers, including nuclear spectrometers	32.9	28.9	27.7	20.4	33.8	27.3	28.9	18.2	18.2	17.6
Count rate meters	.9	1.6	9.1	6.6	4.6	3.9	2.8	3.4	3.1	3.0
Measurement and control devices using beta, gamma, or neutron gauge technology	129.9	106.7	119.1	128.1	133.1	160.4	186.1	90.4	97.8	94.7
Input-output accessories for multichannel analyzers	1.5	1.8	7.6	12.4	10.6	9.9	13.1	8.1	8.7	8.4
Nuclear power supplies	9.4	5.4								
Neutron & photon activation analysis systems										
Nuclear instrument modules	27.7	25.4	17.9	16.9	17.0	29.1	27.6	30.9	46.3	44.8
Other nuclear radiation detection and monitoring instruments	146.8	140.2	74.8	117.4	136.4	119.3	113.1	125.3	137.9	133.6
TOTAL	546.1	489.5	479.7	518.6	559.6	600.7	615.9	606.0	650.8	630.5

r-Revised.
e-Estimated by EIA Marketing Services Department.
SOURCE: U.S. Department of Commerce.

MEDICAL ELECTRONICS

Increases in national health care expenditures, combined with strong international demand, continue to expand the medical electronics market. In 1991, U.S. shipments of electromedical equipment reached an estimated $29.6 billion, compared to $27.8 billion the year before, according to the U.S. Department of Commerce. U.S. shipments of electromedical devices are projected to grow 6.1% in 1992. Growth in this industry could be spurred in the coming years by the aging of the U.S. population as well as U.S. government efforts to limit health care expenditures by promoting increased use of early diagnostic techniques.

The U.S. Department of Commerce reports export growth near 20%, totalling $6.7 billion in 1991, compared to $5.8 billion in 1990. Although the U.S. is the leading supplier of the $65 billion worldwide market, the future of the export market is uncertain as trade issues in the still-evolving European market develop and countries, such as Japan, examine health care priorities.

One aspect of the medical electronics industry—the hospital computer segment—is in a period of dynamic change and growth. The next decade will see the computer become the most significant instrument in hospital management, and ultimately, in the delivery of health care itself. The next few years of this rapid evolution will be critical, both for hospitals purchasing or expanding health care computing systems, and for systems manufacturers.

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Factory Shipments of Electromedical Equipment ($ Millions); United States, 1982-1991

TABLE 3-9

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Diagnostic, Therapeutic, Monitoring and Support Equipment										
Diagnostic Equipment:										
ECGs	88.2	72.3	117.6	78.1	73.3	85.1	98.5	173.0	177.7	191.0
EEGs and EMGs	14.8	14.5	19.6		.9	2.9		20.1	23.6	25.4
Ultrasonic scanning devices	299.5	376.3	294.2	171.9	243.9	336.6	416.8	566.7	659.2	708.6
Audiological equipment		10.2	11.5	12.3	13.6	22.5	17.6	22.8	21.6	23.2
Endoscopic equipment	72.4	3.0	10.2	10.6	25.5	35.2	22.3	12.3	15.6	16.7
Respiratory analysis equipment	17.7	15.6	17.1	*			22.7	41.2	41.5	44.6
Automated blood and body fluid analyzers	641.1	744.3	715.3	631.9	571.6	617.2	579.2	na	na	na
Nuclear magnetic resonance imaging devices	na	360.0	81.2	210.9	250.4	466.0	577.0	640.2	696.4	748.5
Other diagnostic equipment	345.4		254.1	275.8	201.1	322.8	457.7	272.3	299.6	322.0
Therapeutic equipment:										
Pacemakers	319.1	263.5	370.6	293.5	345.1	284.3	496.8	573.5	724.7	779.0
Defibrillators	80.1	85.6	90.7	103.6	118.3	141.3				
Electrosurgical equipment	23.1	63.6	80.5	80.2	100.8	125.2	133.9	135.3	159.6	171.6
Diathermy apparatus and dialyzers	32.6	72.6	65.5	88.9	85.2	94.6	134.6	151.4	148.1	159.2
Ultrasonic therapeutic equipment	9.4	17.9	31.7	27.1	26.0	35.3	30.2	31.3	36.6	39.3
Other therapeutic equipment	241.3	274.4	280.3	224.7	154.1	190.6	233.7	258.5	269.5	289.7
Patient monitoring equipment										
Intensive/coronary care units	271.9	298.1	280.2	352.2	301.7	283.8				
Perinatal monitoring equipment	42.6	70.9	50.9	64.2	67.7	95.6	367.9	379.8	404.1	434.4
Respiratory monitoring equipment							23.0	82.7	89.2	95.9
Other patient monitoring equipment	289.9	289.7	245.7	248.2	228.7	252.4	255.0	311.2	313.0	336.5
Surgical support systems	108.1	103.7	129.5	177.4	216.9	226.7	273.4	392.2	408.2	438.8
Parts and accessories for above	162.9	164.9	244.1	300.8	300.0	386.4	455.9	529.6	659.7	709.2
Irradiation equipment:										
Medical x-ray equipment										
Diagnostic										
Digital radiography	972.1	1,135.3	59.9	31.2	39.1	29.4	38.5	320.1	358.0	384.9
Computerized axial tomography			666.4	528.7	905.3	815.8	704.1	605.2	617.3	663.5
Other			420.3	429.7						
Therapeutic	64.9	66.8	96.5	105.7	115.8	131.6	na	206.9	234.4	252.0
Dental X-ray equipment	26.9	17.0	37.9	45.4	33.4	16.9	na			
Industrial and scientific X-ray equipment	38.1	65.4	52.5	61.0	66.0	71.0	82.0	93.5	95.5	102.7
X-ray equipment accessories	70.7	98.5	137.9	158.5	118.3	117.7	111.1	153.0	188.5	202.6
X-ray tubes	70.5	81.2	158.6	170.9	195.2	218.4	237.9	258.5	247.6	266.2
Parts for X-ray equipment	16.0	22.0	26.4	50.2	49.1	34.5	67.7	77.8	86.8	93.3
Other irradiation equipment	82.8	57.4	101.2	94.1	84.1	135.8	177.4	30.2	33.5	36.0
TOTAL	4,402.1	4,844.7	5,148.1	5,027.7	4,931.1	5,575.6	6,014.9	6,339.4	7,009.6	7,534.7

*Included in "other diagnostic equipment."
r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

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Hospitals and other medical facilities are also increasing their use of other electromedical equipment. The largest product category of this segment is diagnostic and therapeutic equipment, which includes technologies such as electrocardiographs, electroencephalographs, pacemakers, defibrillators, patient monitors, ultrasonic scanners, magnetic resonance imaging devices, and surgical support systems. Examples of these products include ultrasonic, radiologic, and nuclear magnetic resonance imaging devices; sophisticated aids for handicapped persons that can provide limited artificial sight, hearing, and speech; implanted programmable prosthetic devices; automated clinical laboratory analysis units; and computer-based medical information systems that process financial records, patient medical data, medical diagnostic data, pharmacy inventories, and medical service scheduling.

Diagnostic Equipment

U.S factory shipments of diagnostic equipment totaled $2.1 billion in 1991, up 10% from $1.9 billion in 1990 (Table 3-9).

Advances in microelectronics technology have changed medical applications of diagnostic equipment. The use of computers has enhanced the speed, image clarity, and analytical capabilities of medical imaging equipment and other medical devices. Frequently, complex, technology-intensive devices are easy to use because of built-in features for operation, safety, self-calibration, fault diagnosis, and repair. Many raise productivity in the delivery of health care services and reduce unit costs.

Conventional X-ray is still the world's dominant imaging technique and is projected to remain so into the 1990s. *Industrial Outlook '92* forecasts compound annual growth of 3.5% from 1991 through 1996. However, total market share will continue to decrease due to continuing introductions of more advanced technologies.

Digital radiography is a computerized system that is intended to enhance and manipulate X-ray information coming from existing X-ray equipment. Initially well-received by the medical community, digital radiography is experiencing problems because installed systems have not yielded the results physicians anticipated. Digital radiography's second generation integrates digital X-ray systems with X-ray equipment and the computer image-processing system.

The next-largest technology group is composed of computerized axial tomography (CAT) devices, which combine information from numerous narrow-beam X-ray slices of an organ, such as the brain or heart, into a composite image that has a resolution much higher than that possible with conventional X-ray equipment. Although CAT scanners experienced phenomenal growth in the late 1970s, the rate has declined due to competition from nuclear magnetic resonance (NMR), and position emission tomography (PET). New U.S. government regulations intended to limit high health care costs also could have a negative impact on the market for CAT scanners, which are costly—selling in the $1 million range.

While CAT scanners have worked medical miracles for many patients, industry observers predict that nuclear magnetic resonance (NMR), used for diagnosis and monitoring of diseases, will continue to lead the medical imaging field. NMR provides images of the body's interior—similar to those from CAT scanners—without using ionizing radiation, such as X-rays. NMR can detect small changes in body energy, which could help determine whether a tumor is malignant. Theoretically, NMR could identify malignancies at their modular start, and patients could be treated immediately with chemotherapy before their diseases require surgery. NMR may well surpass CAT in viewing the extent of tumors of soft tissues and bone in the extremities. Diagnosing tumors in some areas of the body is difficult with CAT because blood vessels can be confused with tumors. This is not the case with NMR. NMR also appears to have advantages over CAT, in detecting neurological disorders, and ultrasound, for breast scanning.

Positron emission tomography (PET) offers a promising diagnostic imaging technique. PET is capable of detecting very small biochemical changes in the brain and is far more sensitive than X-ray and CAT scanners. The limiting factor in PET technology is the need for a cyclotron capable of producing the short-lived isotopes utilized in the process. Future development of a "table-top" cyclotron or positron emitter, along with other refinements in the radiochemistry, will have a positive impact on the market. At this point, PET is only used for research purposes, but may become more commercially viable as large imaging firms invest in the technology.

Imports and Exports of Computer/Industrial Electronic Equipment by Type, ($ Million); United States, 1990-1991 — TABLE 3-10

	1990r	1991
IMPORTS		
Computers	2,550.5	3,992.4
Monitors	2,430.2	2,978.6
Disk Drives and Blank Computer Media	6,648.3	7,125.9
Printers	2,349.8	2,527.9
Other Computer Peripherals	749.1	794.1
Other Business Machines and Parts	8,203.0	8,783.6
Electromedical Devices and Parts	1,925.7	2,197.5
Industrial Robots	121.2	167.3
Testing/Analyzing Equipment	591.2	618.1
Measuring/Analyzing Equipment	834.4	787.1
Process Control Devices	340.4	336.9
Other Electronic Products	610.8	686.0
TOTAL	27,354.6	30,997.6
EXPORTS		
Computers	7,949.5	8,024.1
Monitors	543.6	648.4
Disk Drives and Blank Computer Media	4,945.0	5,428.3
Printers	1,034.7	1,171.2
Other Computer Peripherals	1,186.5	1,123.1
Other Business Machines and Parts	11,824.7	12,522.3
Electromedical Devices and Parts	2,385.8	2,795.0
Industrial Robots	64.9	78.8
Testing/Analyzing Equipment	1,877.5	2,039.6
Measuring/Analyzing Equipment	2,386.8	2,667.6
Process Control Devices	717.1	841.4
Other Electronic Products	755.9	861.8
TOTAL	35,672.0	38,201.2

r-Revised
SOURCE: U.S. Department of Commerce

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Therapeutic Equipment

U.S. shipments of therapeutic equipment reached an estimated $1.4 billion in 1991, up 7.7% from the 1990 level of $1.3 billion (Table 3-9). The most rapid growth of revenue from therapeutic devices has occurred in the areas of electrical stimulation (used for pain control) and neuromuscular rehabilitation. The number of participants in this highly competitive market is expected to decline in the years ahead as major shakeouts occur in the pacemaker and dialysis manufacturing segments.

Shipment of stimulators such as Transcutaneous Electrical Nerve Stimulation (TENS) units, the major form of therapy used in many comprehensive pain treatment programs, are expected to do well in the therapeutic equipment market. Industry experts predict that TENS units will eventually be used in half of the surgical operations associated with postoperative pain. The therapeutic use of TENS involves placing electrodes at various locations of the body and then applying electrical impulses to the patient through the electrodes.

Microprocessors and microcomputers are playing an increasingly important role in all phases of pacemaker therapy. Such technology is responsible for more than half of the significant advances in cardiac pacing. As pacemaker complexity increases, interest is also growing in pacemaker analyzers (PSA) and other measurement devices that communicate directly with an external mainframe computer or microcomputer to process data. PSAs are battery-powered, microcomputer-based devices used during lead implantation to evaluate the threshold of stimulation and amplitude of signals sensed through the pacing lead. This technology is especially important in pacemaker follow-up, when the availability of complete and accurate data can be very important in solving pacing problems through noninvasive programming rather than surgical intervention.

Assistive Devices

State-of-the-art electronics are also being used to help the hearing impaired. Recently, instrumentation has been developed to effectively provide high-frequency amplification and allow users to amplify sounds in selected frequency ranges. A microcomputer-based system for tuning an experimental hearing aid has been created. The computer adjusts the frequency range response to the patients hearing defect as revealed by audiological data. Adjustments may be made for the tunable parameters of the hearing aid itself, the patient's discomfort level, hearing threshold, and the noise floor in the tuning process. When perfected, such systems are expected to improve the "auditory fit" of modern hearing aids to a patient's hearing loss.

Factory Shipments of Other Electronic Systems and Equipment, ($ Millions); United States, 1982-1991

TABLE 3-11

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Amplifiers (except audio, RF power and video)	55.1	57.6	62.4	53.0	20.1	39.5	37.2	30.5	34.1	33.8
Electronic games: arcade (except coin-operated)	919.9	479.9	283.7	159.8	180.1	258.8	192.4	335.6	261.1	259.2
Automatic garage door openers, electronic	137.3	186.9	197.8	184.4	202.9	232.7	264.6	252.3	261.4	259.5
Ultrasonic equipment: cleaners, drills, solderers and welders	86.4	107.0	127.2	114.2	136.5	93.5	101.3	275.4	248.6	246.8
Trainers and simulators	622.1	770.7	766.9	895.1	969.7	1,112.5	1,156.4	1,303.0	1,025.5	1,018.0
Teaching machines and teaching aids	87.2	21.3	64.3	66.9	34.8	50.6	87.2	56.6	44.9	44.6
Particle accelerator electronic equipment	47.4	33.9	29.1	19.4	14.8	26.2	26.6	na	na	na
Scientific electronic equipment, n.e.c.	211.2	184.8	186.9	120.7	115.9	143.7	126.3	125.8	120.1	119.2
Laser systems and equipment, except communication	507.8	545.2	622.8	684.5	766.0	879.3	894.7	915.6	885.8	879.4
Electronic kits to be assembled by purchaser including computers, receivers, transceivers, transmitter-receivers, amateur equipment, and testing and measuring equipment	292.1	193.8	278.8	na	na	22.5	na	na	na	na
Other electronic systems, equipment, and subassemblies, n.e.c.	902.5	831.3	886.4	1,072.9	1,040.2	937.7	938.4	934.3	991.3	984.1
Industrial blank media and parts	na	na	254.5	254.6	342.7	463.6	634.5	588.3	504.0	500.4
Other industrial related electronic value	na	na	904.2	904.6	896.7	977.7	1,128.3	1,174.0	1,232.0	1,193.5
TOTAL	3,869.0	3,412.4	4,665.0r	4,530.1r	4,720.4r	5,238.3r	5,587.9r	5,991.5	5,608.7	5,538.5

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

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In 1990, the U.S. government enacted the Americans with Disabilities Act (ADA) to prohibit discrimination against the United States' 43 million people with disabilities. The legislation has helped to focus attention on the needs of physically disabled people and on the types of products that can be manufactured for their use. Indeed, a whole realm of products to assist physically impaired people is beginning to reach commercial markets. Included in the category of assistive devices are computer-related products, such as large-print screens, voice-activated computers, and braille printers, and other products, such as "talking" scales, watches, and even wallets.

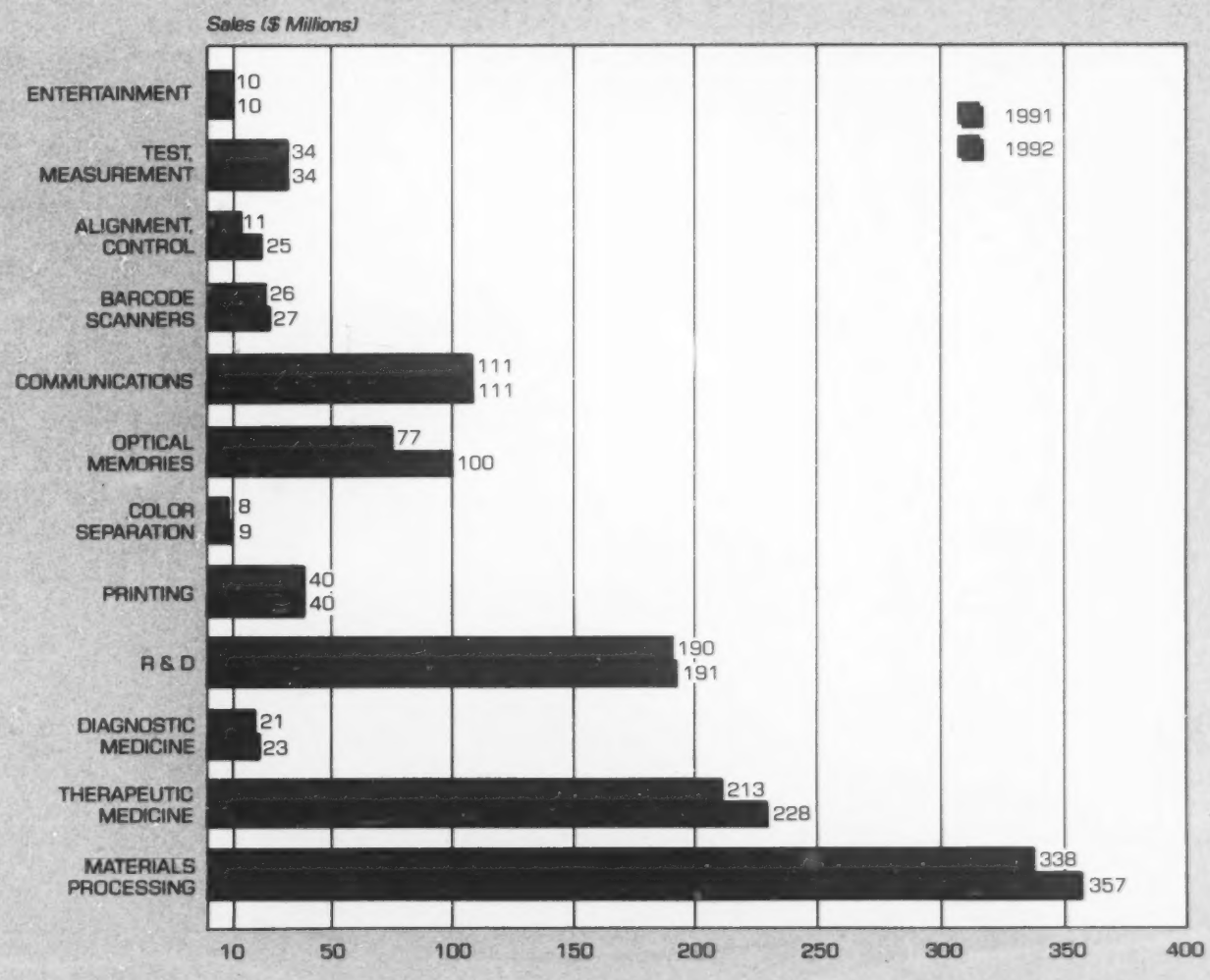
Surgical and Medical Instruments

Within the surgical and operating room instrument market, analysts see laser systems as the area of highest growth, largely because of expanding applications for such systems as laser scalpels and laser surgical "welding" devices. This section highlights medical laser systems, since most of the other types of surgical and medical instruments are non-electronic.

During the past several years, a steady stream of medical reports has shown successful results for laser surgery in a variety of operations. So far, there are three main laser types: the carbon-dioxide (CO_2) laser, used for precise cutting in general surgery; the YAG laser, used for penetrating tissue, coagulating bulky tumors, and stopping bleeding; and the argon laser, used to vaporize superficial lesions, such as port-wine stain on the skin.

According to *Laser Report*, 1991 sales increased in almost all segments of medical lasers, except in the laser laparoscopic cholecystectomy sector, which is a product involved in gallbladder removal. Sales dropped 60% in that segment due to widespread negative feelings about the costs of the laser med-

Laser Device Sales by Application, 1991-1992 FIGURE 3-E



SOURCE: Annual Economic Report, *Laser Report*.

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Commercial Laser Device Sales by Type, 1984-1991 ($ Millions) TABLE 3-12

Laser Type	1984	1985	1986	1987	1988	1989	1990*	1991
Carbon dioxide	89	110	110	120	155	180	298	305
Solid-state	82	96	85	89	144	165	209	228
Ion	71	85	86	88	146	170	143	132
Diode	53	90	121	179	180	210	250	250
He-Ne	38	42	44	49	52	60	53	50
Dye	23	28	31	17	39	44	51	59
Excimer	14	19	19	22	24	29	35	33
He-Cd	4	5	6	6	13	18	10	10
Metal-vapor	na	na	na	na	6	7	12	13
TOTAL	374	475	502	570	759	883	1,060	1,080

na-Not available.
SOURCE: Annual Economic Report, *Laser Report*.

ical procedure compared to costs associated with other technologies used in gallbladder removal. Nevertheless, worldwide sales of laser devices for therapeutic and diagnostic medicine are projected to increase to $228 million in 1992, from $213 million in 1991 (Figure 3-E), primarily due to increased sales of higher cost units in the fields of dentistry, urology, orthopedics, and corneal sculpting.

Patient Monitoring Equipment

The patient monitoring equipment industry has become highly computer-oriented. According to Electronic Industries Association (EIA) estimates, based on U.S. government data, U.S. shipments of patient monitoring equipment reached $867 million in 1991, up 7.6% from $806 million in 1990 (Table 3-9). Patient monitoring equipment is used in the operating room, in intensive and coronary care units, at patients' bedsides, for athletic training, and even for home exercise programs. The equipment continuously monitors an individual's body temperature, heart rate, respiratory rate, and blood pressure.

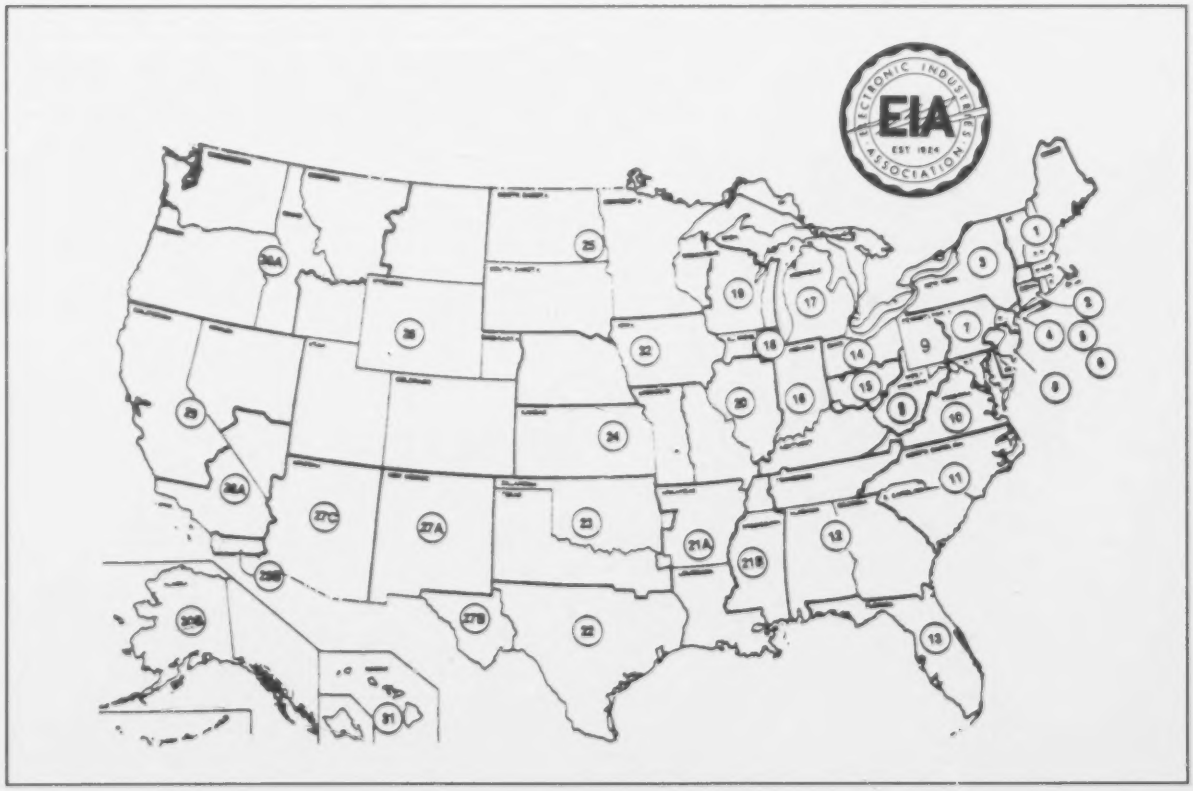
Consumer Medical Electronics

As the U.S. population ages and legislators seek better methods of bringing health care costs under control, home health care appears to be an increasingly attractive alternative. Analysts estimate that more than a million American are using home computers for health, exercise, and diet monitoring. The consumer medical electronics market is considered one of the highest growth areas for electromedical devices. Because of current trends toward preventative medicine and self-care, some observers believe that in the not so distant future, consumers will spend nearly $500 million every year on such electronic medical devices as electronic blood pressure machines, thermometers, pulse rate monitors, birth control devices, and computer software. Soon, software packages for determining life expectancy based on an individual's alcohol consumption, weight, diet, exercise, and degree of hypertension may also be available for home computers.

UNIT TERRITORY PLAN

The Unit Territory Plan was first published over thirty five years ago in recognition of the importance of making intelligently devised sales territories available to manufacturers whose sales are handled, at least in part, through independent representatives. Today, the UTP has found wider application within various industry sectors, and, in these challenging times when "efficiencies" are emphasized, its value continues to grow.

Containing statistical information compiled from EIA's report on "Sales of Electronic Components by Geographic Area", the Unit Territory Plan provides valuable sales data by zip code, by state, and by territory.



For further information or to order a UTP booklet and map, contact: EIA's Components Group, 2001 Pennsylvania Avenue, N.W., Washington, DC 20006; 202/457-4930. **UTP booklets updated with 1991 data to be available this summer!**

4 Electronics Components

U.S factory sales of electronic components totaled $55.97 billion in 1991, up 1.6% compared to sales of $55.09 billion in 1990 (Table 4-1). Electronic components are fundamental to the construction of every electronic product—from consumer electronics products such as camcorders, to military weapons systems such as the Patriot Missile. In fact, the military is one of the largest users of electronic systems.

Components are classified as either "active" or "passive." Semiconductors, the largest segment of active components, amplify or modulate electrical signals, or rapidly switch voltages or currents to generate signals that can be stored (memory), added to, or subtracted from other signals (logic), and then transmitted. A cathode ray tube, a vacuum display tube in which an electron beam strikes a phosphor screen and causes it to glow, is also considered an active component.

Passive components do not contribute to the electrical signals, but simply carry them from one active component to another (wire and cable connectors); or turn them on or off (switches and relays); or tune electrical circuits (capacitors and coils); raise or lower voltages (transformers), or limit current flows (resistors).

In 1991, U.S. factory sales of active components reached $24.5 billion—with semiconductors accounting for $22.0 billion. Passive and other components factory sales in 1991 were $31.4 billion, up 1.5% over such sales in 1990. Active, passive and other components accounted for 21% of total U.S. electronic factory sales in 1991 and 1990 (Table 4-1).

The major technological trends in the electronic components area continue to be miniaturization and the move toward surface-mount technology (SMT) and surface-mount devices (SMD). SMT contributes to a 30 to 40 percent reduction in the size and weight of the component. SMT calls for connecting specially designed electronic components to electrical circuits by soldering them directly to the copper traces or wiring pathways laid out on printed-circuit boards, rather than by mounting them on a board and then soldering the leads to traces on the underside of the board.

According to Market Intelligence Research Company, the SMT manufacturing equipment business is in the strong growth phase of its life cycle. Strong growth in virtually every subsegment is expected to result in a compound annual growth rate of 24.3% over the period 1990-1996, and the total 1996 world market is forecasted to be $4.6 billion.

Assembly time may be cut 80% or more by using surface-mount devices, and the assembly process may be almost completely automated. SMDs are much smaller than leaded components and therefore will fit on smaller boards. Surface-mount passive devices generally average 15-20% annual growth rates, driven by high-volume devices (such as multilayer ceramic and tantalum chip capacitors), according to Electronic Outlook Corp. Ceramic and tantalum capacitors are two of the largest passive component product categories in the North American market.

For the past six years, the Electronic Industries Association (EIA) has co-sponsored, along with the Institute for Interconnecting and Packaging Electronic Circuits (IPC), the annual Surface Mount and Advanced Related Technology (SMART) conference. These conferences have reviewed the latest technological and standardization issues facing the electronics industry. Recently, the EIA and the IPC merged SMART with another surface mount show and conference, owned by the Surface Mount Technology Association and Miller Freeman Exposition Company, to form the Surface Mount International Exposition and Conference, a more comprehensive show and conference for engineering executives involved with SMT. The first Surface Mount International was held August 1991, in San Jose, California.

The balance of trade for electronic components continued to be negative in 1991. With exports of active and passive components totaling $22.4 billion, and imports totaling $23.0 billion, the difference was a negative $639 million. The trade deficit decreased by more than 28.6% in 1991, from the 1990 deficit of $895 million.

According to the *U.S. Industrial Outlook '92*, after a sluggish year in 1991, components are expected to increase slightly by 4.4% in 1992. Semiconductor shipments will be the biggest contributor to the upward trend with an 8% increase expected in 1992.

ELECTRON TUBES

Factory sales of electron tubes totaled $2.56 billion in 1991, down 2.7%, from $2.63 billion in 1990. The most widely used type of electron tube in the United States is the cathode ray television picture tube, which has accounted for almost 60% of all factory sales of electron tubes since 1989. Other types of cathode ray tubes (CRTs) are those used for computer screens, and for oscilloscope displays, and other testing and

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Factory Sales of Electronic Components ($ Million); United States, 1982-1991

TABLE 4-1

DESCRIPTION	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
ELECTRON TUBES										
Receiving Tubes	76	62	36	32	30	28	25	10	5	—
Power & Special Purpose Tubes	925	1,007	1,059	1,061	1,067	1,119	1,171	1,075	1,070	1,023
TV Tubes	884	980	1,042	962	1,028	1,029	1,093	1,511	1,552	1,541
TOTAL-Electron Tubes	1,885	2,049	2,137	2,055	2,125	2,176	2,289	2,596	2,627	2,564
SOLID STATE PRODUCTS										
Transistors	597	626	824	655	688	753	864	711	595	608
Diodes and Rectifiers	655	736	761	755	686	780	855	748	687	702
Integrated Circuits	7,322	8,861	12,960	10,806	10,816	12,851	14,865	16,142	15,423	15,762
Other Semiconductors	2,155	2,347	2,487	2,434	2,220	2,436	3,206	4,645	4,802	4,907
TOTAL-Solid State Products	10,729	12,570	17,032	14,650	14,408	16,819	19,790	22,246	21,507	21,979
PASSIVE AND OTHER COMPONENTS										
Capacitors	1,169	1,277	1,619	1,200	1,223	1,411	1,534r	1,536	1,412	1,393
Resistors[1]	583	638	698	587	586	658	682	717	757	740
Passive Networks	138	153	226	193	159	168	181	186	180	180
Coils and Transformers	842	966	1,055	1,179	1,042	1,149	1,183	1,100	941	962
Connectors	2,148	2,586	3,200	2,901	3,026	3,629	3,748	3,593	3,431	3,506
Switches	448	512	548	577	537	692	625	644	590	603
Filters	142	167	232	178	210	233	190	183	184	188
Quartz Devices	266	257	340	338	319	395	381	248	232	238
Wire and Cable	1,304	1,386	1,613	1,475	1,409	1,662	1,772	1,869	1,716	1,652
Relays	282	296	552	631	588	596	507	530	472	459
TV & FM Antennas and Parts	83	80	72	72	76	71	69	63	61	64
Other Components[2]	9,544	10,919	13,982	13,423	13,121	15,676	18,038	20,869	20,984	21,446
TOTAL-Passive and Other Components	16,947	19,237	24,137	22,754	22,296	26,340	28,910	31,538	30,960	31,431
GRAND TOTAL	29,561	33,856	43,306	39,459	38,829	45,335	50,989r	56,380	55,094	55,974

[1]U.S. consumption.
[2]Includes sockets, delay lines, loudspeakers, magnetic components, transducers, printed circuit boards, microwave components, other components, assemblies and parts.
r-Revised.
e-Estimated.
SOURCES: EIA Marketing Services Department, U.S. Department of Commerce.

measuring devices. Sales of microwave tubes, used in radar and telecommunications, accounted for about 14% of total electron tube industry sales, down slightly, from 15% in 1990. Other types of tubes include high-vacuum, gas and vapor, special-purpose tubes, and various other electro-optical devices.

In 1991, the balance of trade in electron tubes showed a surplus of $109.9 million, up substantially from the 1990 trade surplus of $2.4 million. Imports increased 6% in 1991 to $545.7 million, while exports increased 27% over 1990, reaching $655.6 million.

Sales of some electron tubes are expected to stay constant over the next several years, with TV manufacturers' needs for additional picture tubes and a trend toward non-defense market applications expected to off-set the decrease in sales of other tubes. While semiconductors continue to replace some categories of tubes, they cannot replace CRTs, and so far they cannot generate the power required for such microwave tube applications as long-range radar and communications systems.

Television Picture Tubes

Factory sales of TV picture tubes were placed at 14.98 million units in 1991, up 2.2% over 1990 (Table 4-2). Dollar sales of TV picture tubes are estimated to have declined a slight 0.7% in 1991, to a reported $1.54 billion. The average price of a color TV picture tube dropped 2.8%, from $106 in 1990, to $103 in 1991.

Color tubes accounted for nearly all of factory sales of TV tubes in 1991 in both units and dollars. Exports accounted for 20% of unit sales of color TV tubes in 1991, as compared with 15% in 1990. The brightest spot for television tubes will be in sales of 30-inch and over types. According to *TV Digest*, one industry representative predicts that 30-inch tubes will double in sales by 1993.

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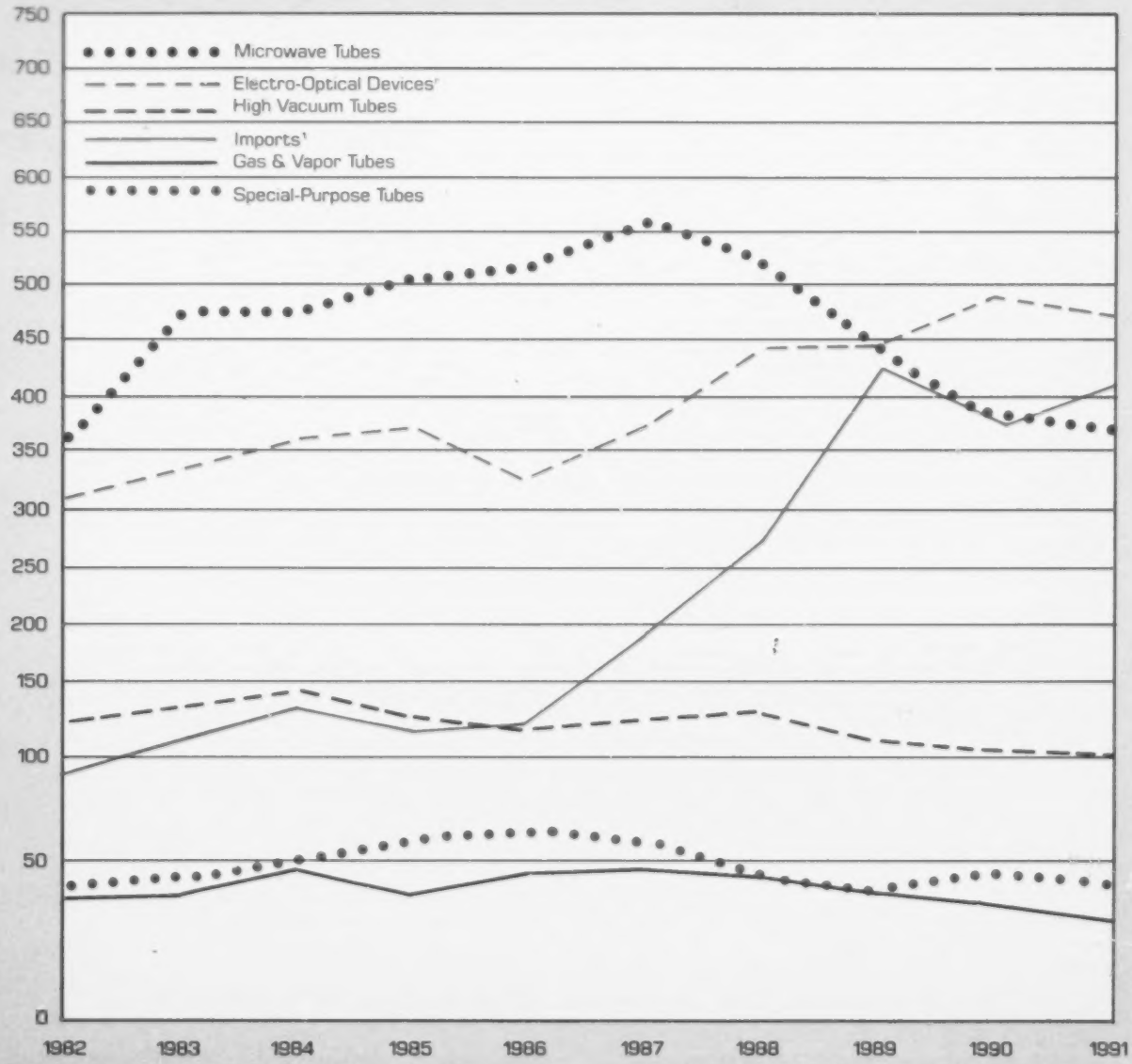
For the past ten years, all sales of monochrome (black-and-white) tubes were for export. Exports are estimated to have increased 17% in 1991, reaching 63.2 thousand units. In dollars, the estimated increase was 43.6%, from $4.3 million in 1990 to $6.2 million in 1991.

The dominant technological development in the industry will be flat-panel displays and High Definition Television (HDTV), currently being worked on by United States, European, Korean, and Japanese manufacturers.

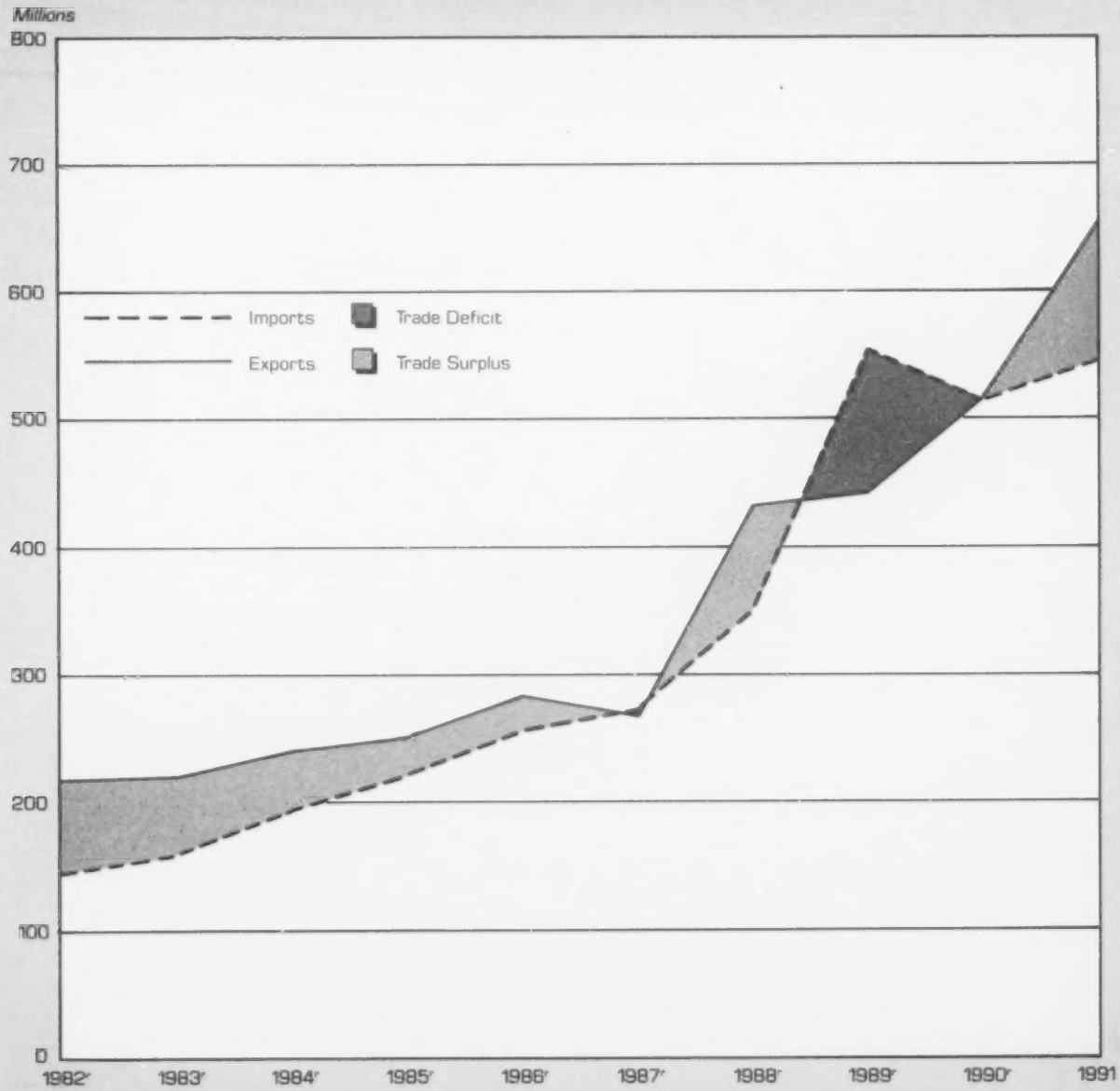
The three most widely manufactured flat-panel displays include active-matrix LCD, plasma, and electroluminescence; and all were invented in the U.S. According to Stanford Resources, the worldwide market is currently $3.8 billion. The active-matrix display, which is used in many laptop computers, consists of two sheets of polarizing material with a layer of liquid crystal solution between them. Active-matrix displays have a transistor for each pixel (picture element—the smallest unit of a monitor's image). When the transistor

Sales of Power, Transmitter & Special-Purpose Tubes by Type ($ Million); United States, 1982-1991 FIGURE 4-A



r-Revised.
¹The 1982-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and achieve compatability between the trade data and domestic factory sales data.
SOURCE: EIA Marketing Services Department.

Imports and Exports of Electron Tubes ($ Million); United States, 1982-1991 FIGURE 4-8



r-The 1982-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and achieve compatability between the trade data and domestic factory sales data.
SOURCE: U.S. Department of Commerce.

is turned on, it causes the crystal to twist, allowing light to emanate through it. According to Nomura Research Institute, the flat-panel display market worldwide is estimated to increase from $1.45 billion, to $7.25 billion by 1995, and reach $14.5 billion by the year 2000. The average annual growth rate for LCDs through the decade is expected to be 35%, while growth for active-matrix LCDs will be 80%.

Power and Special-Purpose Tubes

Sales of power, transmitter, and special-purpose tubes are estimated at $1.02 billion in 1991, down about 4.4% from 1990 (Table 4-4).

Microwave tubes accounted for 36% of all power, transmitter, and special-tube sales—and over 58% of these were trav-

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Factory Sales of Television Picture Tubes by Screen Size (Thousands of Units and Dollars); United States, 1982-1991[1]

TABLE 4-2

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Color Units										
12" & Under	123.4	[3]	[3]	[3]						
13"	948.2	1,199.1	1,646.5	911.6						
14"	13.0	169.6	172.5	77.9						
15"		32.5	42.0	9.3						
16"		.3	—							
17"	293.0	156.0	105.3	30.8						
18"		.7	3.8	3.4	11,684.3	12,229.4	13,747.4	15,027.2	14,599.7r	14,915.8
19"	5,485.0	6,306.4	6,423.0	6,095.0						
20"		6.8	1.3							
21"	199.7									
22" and 23"	941.3	94.0	43.8							
24" and 25"	1,932.7	3,443.2	3,956.1	4,193.3						
26" and Over		155.9	350.9							
TOTAL (Units)	9,936.3	11,564.5	12,745.2	11,321.3	11,684.3	12,229.4	13,747.4	15,027.2	14,599.7r	14,915.8
TOTAL (Dollars)	$883,704	$978,854	$1,041,374	$961,405	$1,026,687	$1,026,409	$1,088,912	$1,508,595	$1,548,136r	$1,535,043
Monochrome[2]										
TOTAL (Units)	7.4	10.3	20.0	5.6	16.4	66.4	89.8	28.4	54.1	63.2
TOTAL (Dollars)	$585	$876	$629	$475	$1,109	$2,624	$4,224	$2,249	$4,327	$6,215
GRAND TOTAL (Units)	9,943.7	11,574.8	12,765.2	11,326.9	11,700.7	12,295.8	13,837.2	15,055.6	14,653.8r	14,979.0
GRAND TOTAL (Dollars)	$884,289	$979,730	$1,042,003	$961,880	$1,027,796	$1,029,033	$1,093,136	$1,510,844	$1,552,463r	$1,541,258

[1]Excludes imports and sales by non-reporting rebuilders. Data subsequent to 1985 exclude all renewal equipment.
[2]Data exclude initial equipment.
[3]Included in 14"
r-Revised.
SOURCE: EIA Marketing Services Department, U.S. Dept. of Commerce.

eling wave tubes, which are mostly used in defense. Electro-optical tubes, including cathode ray tubes other than TV picture tubes, accounted for 46% of power, transmitter, and special-tube sales. The balance were high-vacuum, gas and vapor, and special-purpose tubes, such as vacuum capacitors, switches & relays, radiation detection tubes, and miscellaneous special-purpose tubes.

The government market currently constitutes the largest share of the power and special-purpose tube business, but declining defense budgets are expected to continue to have a negative impact.

High-Vacuum, Gas & Vapor and Special-Purpose Tubes

Factory sales of high-vacuum, gas and vapor, and special-purpose tubes are estimated to have reached $178 million in 1991, down nearly 6% from 1990's $189 million (Table 4-4). This decline was primarily attributed to a substantial decrease in sales of high-vacuum tubes.

Essentially, these tubes are power tubes used in radio frequency applications, with the military being one of the largest users. They include diodes, triodes, thyratrons, ignitrons, and related types of tubes. Power tubes are being phased out as the capacity of power semiconductors increases. As a consequence, the market is largely one of spares and replacements, which will shrink as equipment now in use is replaced by solid state equipment.

Sales of high vacuum tubes (diodes, triodes, and multi-grid external anodes, UHF planar and pencil tubes, and multi-grid internal anodes) continued a decline which started in 1988, decreasing 5%—from $107 million in 1990, to $102 million in 1991. Sales of gas and vapor tubes (diodes, thyratrons, ignitrons, gas duplexers, spark gaps, and noise sources) declined 14%, to $32 million in 1991. Sales of special-purpose tubes, estimated at $44 million in 1991, were down slightly from $45 million in 1990. This category includes radiation detection tubes, vacuum capacitors, switches & relays, and other types of special-purpose tubes.

Imports of vacuum diode, triode, tetrode and gas and vapor tubes increased a substantial 11% in 1991, reaching $12.4 million. Exports of these products increased 7%, from $46 million in 1990 to $49 million in 1991.

The outlook for unit sales of these power tubes is to gradually decline. Estimates gathered by the Electronic Industries Association (EIA) show that overall dollar sales will decline more than 3% a year, in constant 1991 dollars, through 1995.

Electro-Optical Devices

Factory sales of electro-optical devices are estimated to have totaled $475 million in 1991, down 2.5% over 1990 sales (Table 4-4). During 1991, industrial and military (I&M) CRTs accounted for an estimated 11% of total electro-optical device sales.

According to the EIA, there will be an increase in photomultiplier tube sales for the next one to three years, assuming the Federal Aviation Administration (FAA) succeeds in requiring bomb detectors in all major airports. Environmental analysis equipment needs will have an upsurge effect on the shipments of photomultiplier tubes, as well. The market for

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Factory Sales of Television Picture Tubes by Market (Thousands of Units and Dollars); United States, 1982-1991[1] TABLE 4-3

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Color Units										
Initial Equipment	9,274.6	10,737.0	11,975.0	10,719.6	10,810.2	11,716.3	12,152.6	13,387.7	12,402.0r	11,924.9
Renewal	354.7	337.4	312.2	285.9	na	na	na	na	na	na
Export	307.0	490.1	458.0	315.6	674.1	513.1	1,594.6	1,639.5	2,197.7	2,990.9
TOTAL (Units)	9,936.3	11,564.5	12,745.2	11,321.3	11,684.3	12,229.4	13,747.4	15,027.2	14,599.7r	14,915.8
TOTAL (Dollars)	$883,704	$978,854	$1,041,374	$981,405	$1,026,687	$1,026,409	$1,088,912	$1,508,595	$1,548,136r	$1,535,043
Monochrome Units										
Initial Equipment	—	—	—	—	—	—	—	—	—	—
Renewal	na	na	na	na	na	na	na	na	na	na
Export	7.4	10.3	20.0	5.8	16.4	66.4	89.8	28.4	54.1	63.2
TOTAL (Units)	7.4	10.3	20.0	5.8	16.4	66.4	89.8	28.4	54.1	63.2
TOTAL (Dollars)	$561	$876	$629	$475	$1,109	$2,624	$4,224	$2,249	$4,327	$6,215
GRAND TOTAL (Units)	9,943.7	11,574.8	12,765.2	11,326.9	11,700.7	12,295.8	13,837.2	15,055.6	14,653.8r	14,979.0
GRAND TOTAL (Dollars)	$884,289	$979,730	$1,042,003	$981,880	$1,027,796	$1,029,033	$1,093,136	$1,510,844	$1,552,463r	$1,541,258

[1]Excludes imports and sales by non-reporting rebuilders.
na-Not Available.
r-Revised.
SOURCE: EIA Marketing Services Department, U.S. Dept. of Commerce.

photoemissive camera tubes will continue to decline as solid state cameras continue to gain market share. Further improvements in solid-state sensors in the areas of noise reduction and signal processing will make operation at lower light levels possible, reducing the need for intensification.

The market for special-purpose I&M cathode ray tubes will increase less than 10% during the next five years; however, flat-panel displays will begin to gain market share. Cathode ray tubes are still advantageous in the areas of resolution, brightness and full color capability. Laser system applications will continue to grow in the markets for monochrome displays and electronic recording for medical records and typesetting.

Microwave Tubes

U.S. factory sales of microwave tubes, including klystrons, magnetrons, CFAs and forward & backward wave tubes totaled $370 million in 1991, down 6% from 1990 sales of $394 million (Table 4-4). Of these, forward and backward wave tubes have recorded steady declines since 1988.

Sales[1] of Power and Special Purpose Tubes ($ Million); United States, 1982-1991 TABLE 4-4

CATEGORY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
High-vacuum tubes	122	126	135	114	112	113	122	111	107	102
Gas and vapor tubes	32	32	40	33	41	42	42	41	37	32
Klystrons	104	111	103	92	84	74	76	65	62	67
Magnetrons/CFAs	83	92	85	77	78	85	100	80	82	85
Forward and backward wave tubes	233	271	289	319	347	383	343	289	250	218
Electro-Optical devices[2]	314	330	357	371	345	368	445	447	487r	475
Special Purpose Tubes[3]	37	45	50	55	60	54	43	42	45	44
TOTAL	925	1,007	1,059	1,061	1,067	1,119	1,171	1,075	1,070r	1,023

[1]Excludes R&D Billing.
[2]Excludes entertainment TV picture tubes.
[3]Includes radiation detection tubes, reference cavities; beam deflection tubes; decade counters; mechanical transducers; orbital beam tubes; and vacuum capacitors, switches and relays.
r-Revised.
SOURCE: EIA Marketing Services Department.

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Microwave tubes find their primary applications in high and ultrahigh frequency applications—especially radar and communications systems. In recent years, the U.S. microwave tube industry expanded its floor space by 25%. There is excess capacity and a lack of planning information. Difficult times will continue for the next two to three years. As defense spending declines, a trend toward non-defense applications will be pursued.

Overall sales of microwave tubes, through 1995, will be affected by aggressive competitive pricing, decreased production of all major weapons platforms, delayed production of start-up on new platforms, and increased use of new monolithic microwave integrated circuit technology (MMIC). This technology consists of an integrated circuit on a single chip, containing no discrete components associated with distributed arrays.

Sales of traveling-wave tubes (TWTs) and backward-wave oscillators (BWOs) totaled $218 million in 1991, down almost 13% from 1990. Continuous-wave TWTs accounted for $98.3 million; pulsed TWTs accounted for $112 million; and BWOs more than $7 million. Sales of klystrons totaled $67 million in 1991, up more than 8%. Sales of magnetrons and cross-field amplifiers (CFAs) increased slightly to $85 million in 1991.

The biggest single market for microwave tubes is radar systems, both airborne (including missiles) and surface and shipboard. The next largest market is for electronic countermeasures (ECM), including decoys and related equipments, which will grow and provide a positive stimulus to the microwave tube sector. However, this force will be somewhat offset by the growing use of solid state products. Some of the major weapons using radar systems incorporating TWTs are MILSTAR, NESP, Aegis, Patriot, and AMRAAM. ECM applications include ASPJ and ALQ-162. TWTs for ECM applications will account for close to 50% of all TWT production, while TWTs account for two-thirds of all microwave tube shipments. The trend in TWTs is toward low-cost tubes, directed beam systems in EW (Early Warning), distributed antenna arrays, and generally lower power, low-noise devices with broad bands.

While a substantial part of the growth in this market is expected to be in TWTs, sales of magnetrons are estimated to drop 15% over the next four years. Klystrons used in large high-power radars are increasingly being replaced by solid state phased-array systems. Heightened demand can be expected for klystrons for LINACS, storage rings, isotope separators, and free-electron lasers and fusion, with total sales of klystrons expected to decline less than 2% by 1995. Sales of BWOs are also expected to decline over the next four years.

Balance of Trade of Electron Tubes ($ Million); United States, 1982-1991 TABLE 4-5

YEAR	IMPORTS	EXPORTS	BALANCE OF TRADE
1982r	144.3	218.1	+ 73.8
1983r	159.9	219.8	+ 59.9
1984r	194.7	241.2	+ 46.5
1985r	218.5	250.9	+ 32.4
1986r	255.2	282.3	+ 27.1
1987r	268.9	266.2	− 2.7
1988r	347.1	430.8	+ 83.7
1989r	552.1	438.5	−113.6
1990r	515.1	517.5	+ 2.4
1991	545.7	655.6	+109.9

r-The 1982-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and achieve compatability between the trade data and domestic factory sales data.
SOURCE: U.S. Department of Commerce.

Imports of Electron Tubes ($ Million); United States, 1987-1991 TABLE 4-6

	1987[1]	1988[1]	1989[1]	1990[1]	1991
TV Picture Tubes, Color	62.5	54.7	73.7	72.8	69.5
TV Picture Tubes, B/W	2.1	2.3	1.8	7.6	4.8
TV Picture Tubes, Projection	17.6	22.5	48.3	60.0	65.4
Cathode Ray Tubes, N.E.S.	44.1	122.2	274.0	239.9	264.0
Receiving Tubes	6.1	5.3	4.3	3.1	2.7
Gas and Vapor Tubes	18.6r	5.8	1.5	1.3	1.2
Diode, Triode and Tetrode Tubes	3.4	6.5	8.0	9.9	11.2
Magnetrons[2]	51.4	50.5	60.7	36.8	39.4
Klystrons	5.6	10.1	9.3	10.1	14.8
Other Microwave Tubes	14.3	9.8	22.7	26.7	24.6
Light Sensing Tubes	14.2	15.3	32.6	34.6	38.4
Other Light Tubes (Light Emitting)	29.0	42.1	15.2	12.3	9.7
TOTAL	268.9r	347.1	552.1	515.1	545.7

r-Revised.
[1]The 1987-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and achieve compatability between the trade data and domestic factory sales data.
[2]Includes magnetrons for microwaves.
SOURCE: U.S. Department of Commerce.

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Based on Electronic Industries Association (EIA) surveys, sales of cross-field amplifiers, which make up about 41% of the magnetron/CFA category, are expected to rise about 25% from 1991 to 1995.

According to EIA, research and development (R&D) expenditures for microwave tubes increased 20% in 1991, to $19.6 million. This was an increase from 4.1% of sales in 1990 to a little over 5% in 1991. Research and development expenditures are expected to decline very slightly in absolute terms, dropping just below 4.8% of sales in 1995.

Imports and Exports of Electron Tubes

U.S. exports of electron-tube products reached $655.6 million in 1991—up 27% from 1990 (Table 4-7). Exports of electron tubes represented nearly 26% of sales of electron tubes in 1991, up from 20% in 1990.

Electron tubes recorded a balance-of-trade surplus for the second consecutive year, ending 1991 with a surplus of $109.9 million.

Imports of TV picture tubes totaled $139.7 million, down less than 1% from 1990 imports of $140.4 million. Imports of electro-optical tubes, including other CRTs, totaled $312 million, up almost 9%. Imports of microwave tubes increased 7%, from $73.6 million in 1990, to 78.8 million in 1991. Imports of receiving tubes dropped from $3.1 million, to $2.7 million. Imports of high-vacuum, gas, and vapor tubes totaled $12.4 million, up 11% from 1990.

Exports of TV picture tubes were $342.6 million in 1991, up 38% from 1990. Exports of electro-optical tubes increased 33% to $172.6 million. Exports of microwave tubes decreased

Exports of Electron Tubes ($ Million); United States, 1987-1991

TABLE 4-7

	1987r	1988r	1989r	1990r	1991
Receiving Tubes	5.7	11.9	4.1	5.4	5.5
TV Picture Tubes, B/W	2.6	4.2	2.2	4.3	6.2
TV Picture Tubes, Color	48.8	129.4	165.2	244.1	336.4
Cathode Ray Storage Tubes	6.2	7.3	19.2	26.9	13.2
Cathode Ray Tubes, N.E.S.[1]	50.7	79.2	103.2	86.2	143.6
Gas and Vapor Tubes	8.7	10.7	9.0	6.7	8.3
Diode, Triode and Tetrode Tubes	33.2	40.6	37.4	38.9	40.6
Photomultiplier Tubes	25.1	36.9	18.2	16.6	15.8
Klystrons	6.5	9.6	14.7	14.0	13.2
Magnetrons	9.6	10.9	11.6	12.4	12.8
Traveling Wave Tubes & BWOS	52.6	67.6	53.7	62.0	60.0
Electron Tubes, N.E.S.	16.5	22.5	na	na	na
TOTAL	266.2	430.8	438.5	517.5	655.6

[1]Includes TV Camera Tubes.
r-The 1987-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and achieve compatability between the trade data and domestic factory sales data.
na-Not available.
SOURCE: U.S. Department of Commerce.

Imports of Color TV Picture Tubes by Country of Origin (Number of Units and Dollars); United States, 1987-1991

TABLE 4-8

	1987		1988		1989		1990		1991	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
United Kingdom	—	—	*	*	*	*	*	*	*	*
Canada	217,907	15,537,703	80,119	9,119,409	70,681	9,059,909	2,394	398,520	48,321	5,710,540
Taiwan	41,423	2,033,358	14,383	668,389	15,743	992,477	56,767	2,775,644	100,987	4,580,787
Japan	147,485	31,246,754	94,791	43,200,987	122,301	56,385,184	146,620	53,855,611	109,459	46,263,304
Korea	269,226	10,667,313	14,977	934,679	21,885	1,271,305	34,472	3,144,521	6,075	384,784
China[1]	—	—	—	—	—	—	—	—	19,485	1,490,603
Germany[1]	—	—	—	—	—	—	—	—	47,498	10,645,351
Other	9,561	1,078,751	3,827	761,593	66,452	6,036,491	119,150	12,552,123	1,566	450,347
TOTAL	731,765	62,480,849	208,097	54,685,057	297,062	73,745,366	361,682	72,835,080	333,391	69,525,716

*Figures for countries with less than 2000 units are included in "Other."
[1]Prior to 1991, China and Germany included in "other".
SOURCE: U.S. Department of Commerce.

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Imports of Monochrome Picture Tubes (Number of Units and Dollars); United States, 1987-1991 TABLE 4-9

	1987	1988	1989	1990	1991
Units	57,001	48,500	27,236	70,135	115,630
Dollars	$2,100,479	$2,329,319	$1,816,128	$7,632,118	$4,766,806

SOURCE: U.S. Department of Commerce.

almost 3%, to $86 million, while exports of high-vacuum, gas, and vapor tubes grew 7%, to $48.9 million in 1991.

SOLID STATE PRODUCTS

Total U.S. factory sales of solid state products, or semiconductors, totaled nearly $22 billion in 1991, a 2% increase over 1990 (Table 4-10).

There are three distinct categories of solid state products: integrated circuits (ICs), discrete (or individual) semiconductors, and "other" semiconductors, including light-sensitive or light-emitting devices. Sales of ICs reached $15.8 billion in 1991; sales of discretes totaled $1.3 billion; sales of other semiconductors devices came to $4.7 billion.

Discrete Semiconductors

Sales of discrete, or individual, semiconductors totaled $1.31 billion in 1991, an increase of 2.2% from 1990 sales of $1.28 billion.

Discrete semiconductors may be transistors, which can amplify electrical signals. However, they are most often used as digital switches—turning an electric current on or off. They may also be diodes or rectifiers, which for the most part are used to convert alternating current, or AC signals, to direct current, or DC signals. Both transistors and diodes may be "signal" devices, which can handle up to half an ampere of current (half a watt, in the case of transistors), or "power" devices, which can handle greater loads.

While there continue to be applications which call for signal transistors and diodes, the trend is to replace these discrete devices with integrated circuits. In contrast, as the current carrying capacity of power transistors and diodes increases, these discrete devices tend to replace power and special-purpose electronic tubes. One technical development that has become more significant is the use of "on-board" logic circuits to control power semiconductors—resulting in the so-called "smart power circuit."

Integrated Circuits

Factory shipments of integrated microcircuits, usually called integrated circuits or ICs, reached $15.8 billion in 1991, up 2.2% from $15.4 billion in 1990. Integrated circuits are semiconductor networks in a single package. Most ICs are monolithic, with all functions on a single chip. Monolithic ICs function as memories, logic circuits, or as microprocessors, which are groups of logic circuits that form the heart of calculators or computers. Some ICs are hybrids, with several little chips combined on a single silicon substrate. ICs may be linear, which means they function in analog circuits, where the electrical signals vary in strength or amplitude (or sometimes, in frequency); or they may be digital, functioning in circuits where the signals are either "on" or "off"—1 or 0.

There are two basic technologies for manufacturing monolithic ICs—bipolar, and metal oxide silicon (MOS). Bipolars are more difficult to manufacture, but they are faster and, consequently, find their greatest applications in high-speed computers. They account for slightly less than half of all monolithic ICs, and are used mostly as logic circuits. In contrast, more than 40% of MOS ICs are used as memories, and another third are used as microprocessors or microcontrollers.

The semiconductor industry continues to earmark large sums of money for research and development. One important technological trend is the move toward greater chip density. There is a shift away from 4- and 8-bit microprocessors to 16- and 32-bit; and, in both random-access memories (RAMs) and read-only memories (ROMs), a shift away from 128-bit and smaller memories toward 256-bit, 1 megabyte and even higher capacity memories.

Another trend is toward the use of gallium arsenide (GaAs) in place of silicon as substrate material. While silicon is still used for the majority of all monolithic ICs, GaAs offers higher speeds, lower power dissipation, and higher resistance to radiation, which makes it of special interest to the military. However, while GaAs is very brittle, and tends to break during processing, it now appears practical to grow GaAs crystals on silicon substrates, which will result in combining the electrical advantages of GaAs with the better physical properties of silicon. The defense industry has been a driving force behind the GaAs IC industry, accounting for nearly 53% of revenues in 1990. However, demand from other sectors will detract from the defense side by 1995, according to BIS Strategic Decisions, a market research firm. The computers and communications sectors will be the largest beneficiaries of this trend.

A third technological trend is toward customizing or semi-customizing chips, particularly in application-specific integrated circuits (ASICs). The advantages of semi-custom devices over full-custom devices are lower nonrecurring costs—for engineering, tooling, etc.—shorter lead times, and lower prices.

The major technological thrust for the development and use of application-specific integrated circuits is to develop specialized systems knowledge in areas like microprocessors,

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Factory Shipments of Solid State Products ($ Million); United States, 1982-1991

TABLE 4-10

	1982	1983	1984	1985	1986	1987	1988	1989r	1990e	1991e
INTEGRATED MICROCIRCUITS (SEMI-CONDUCTOR NETWORKS)										
Hybrid integrated circuits, thick film composed of material deposited by silk screen process on a passive substrate combined with discrete active or passive components.	434.7	468.4	639.2	557.7	547.8	800.3	863.1	893.3	847.8	866.4
Hybrid integrated circuits, thin film composed of material deposited by vacuum deposition, sputtering or similar process	215.8	261.6	315.9	527.5	520.8	489.8	517.8	463.1	601.4	614.7
Hybrid integrated circuits, multichip; circuits not incorporating film techniques. These are usually combinations of chips, active and/or passive. Discrete package devices may be used for some, but not all of the circuits.	204.0	81.7	95.4	82.8	79.2	91.8	149.0	112.8	135.7	138.7
Monolithic bipolar integrated circuits:										
DTL (diode transistor logic)	8.5	na	na[1]	na[1]	na[1]	na[1]	na[1]	na[1]	na[1]	na[1]
TTL (transistor transistor logic)	1,123.8	1,310.8	2,746.1	2,141.6	2,057.4	1,783.3	1,749.3	1,868.6	1,392.9	1,423.5
CML/ECL (current mode logic/emitter coupled logic)	190.3	113.4	247.9	287.8	215.3	404.3	280.1	271.1	206.3	210.9
Linear bipolar, excl. microprocessors	na	na	885.2	1,070.0	1,227.5	1,454.3	1,730.0	1,748.6	1,488.6	1 521.3
Microprocessors	[1]	100.8	216.6	66.7	39.6	47.6	53.2	44.4	40.9	41.8
Other bipolar logic	[1]	1,221.5	437.1	483.9	243.0	402.1	544.9	403.3	178.8	182.7
Random access memories	na	na	85.8	77.2	63.1	152.3	97.6	53.4	55.8	56.9
Read only memories	na	na	20.1	71.9	75.3					
Other bipolar memories	na	na	211.3	162.5	174.6	114.5	171.9	205.3	172.6	176.4
Other bipolar integrated circuits	821.2	na	368.0	368.5	434.9	538.1	348.8	736.4	776.1	795.2
MOS (metal oxide semiconductors)	3,559.2	4,895.9	8,119.1	4,702.8	4,719.9	6,089.7	7,956.4	8,990.1	9,087.5	9,287.5
Other monolithic integrated circuits	764.2	406.8	572.4	225.1	417.2	482.4	402.5	351.3	436.8	448.4
TOTAL	7,321.7	8,860.7	12,960.1	10,806.0	10,815.6	12,850.5	14,864.6	16,141.9	15,422.9	15,762.2
TRANSISTORS										
Signal (less than 1 watt dissipation)	250.6	272.5	384.1	263.2	282.9	294.7	335.8	240.8	201.1	205.5
Power (1 watt or greater dissipation)	348.2	353.3	439.6	392.1	404.7	458.4	528.3	469.8	394.1	402.8
TOTAL	598.8	625.8	823.7	655.3	687.6	753.1	864.1	710.6	595.2	608.3
DIODES AND RECTIFIERS										
Signal diodes and assemblies thereof (maximum current 0.5 amps)	100.1	136.9	162.2	129.0	100.7	110.8	141.8	54.9	48.8	49.9
Semiconductor rectifiers/Power diodes and assemblies thereof (current rating greater than 0.5 amps)	212.3	208.7	217.7	323.6	287.2	344.7	362.9	335.2	311.1	318.0
Zener diodes (voltage regulator and voltage reference diodes)	97.6	100.4	179.1	140.6	148.9	141.1	166.1	165.5	153.3	156.7
Microwave diodes (mixers, detectors, varactors, parametric, harmonic generators, etc.)	80.5	92.3	99.3	110.2	111.5	133.1	131.4	127.4	110.3	112.7
Selenium rectifiers	3.0	2.8	3.3	2.8	2.8	3.9	4.7	4.2	4.0	4.0
Light emitting diodes (LED)	161.8	195.0	99.1	48.1	34.4	46.4	48.1	61.1	59.2	60.6
TOTAL	655.1	736.1	760.7	755.3	685.5	780.0	855.0	748.3	686.8	701.9
OTHER SEMICONDUCTOR DEVICES										
Light sensitive and light emitting devices:										
Solar cells	46.2	47.8	48.5	33.5	36.6	48.1	47.5	30.8	38.1	39.0
Photodiodes	[2]	[2]	10.4	11.3	14.9	26.8	39.0	40.6	40.5	41.4
Optical coupled isolators	[2]	[2]	65.9	69.6	73.7	47.9	77.0	83.3	80.4	82.2
Other light sensitive/emitting devices	117.5	131.4	188.1	128.6	102.7	99.2	143.4	165.7	159.6	163.1
Thyristors (SCR's, triacs, PNPN diodes)	87.0	94.1	126.2	125.4	137.6	108.9	142.6	108.8	114.9	117.4
All other semiconductor devices	170.3	245.4	305.8	287.5	282.4	479.0	480.6	554.6	649.9	664.2
Semiconductor parts:										
Semiconductor devices and circuits "chips" (DICE) and wafers (DISCS)	1,390.4	1,313.5	1,162.4	1,152.7	944.1	1,169.7	1,617.5	2,172.2	2,337.8	2,389.2
All other semiconductor parts (headers, packages, heat sinks, other accessories, etc.)	343.7	515.4	579.9	825.5	627.7	436.1	678.7	1,488.9	1,380.2	1,410.5
TOTAL	2,155.1	2,347.6	2,487.2	2,434.1	2,219.7	2,435.7	3,206.3	4,645.0	4,801.5	4,907.1
GRAND TOTAL	10,728.7	12,570.2	17,031.7	14,650.7	14,408.4	16,819.3	19,790.0	22,245.7	21,506.4	21,979.6

[1]Included in "Other bipolar integrated circuits."
[2]Included in "Other light sensitive/emitting devices."
r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

digital signal processors, video processing, voice recognition, and radio frequency engineering.

As for the trends in ASICs manufacturing, there will be an increased use of application-specific standard parts (ASSPs), leading to an attempt by firms to gain more leverage from their specialized knowledge of the markets and systems, according to BIS Strategic Decisions.

The latest technological trend in semiconductors is "flash" technology. These devices are smaller, lighter, more durable and more power-efficient than traditional methods of long-

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Imports and Exports of Solid State Products ($ Million); United States, 1990-1991 TABLE 4-11

	1990	1991
Imports		
INTEGRATED CIRCUITS		
Monolithic, Linear	1,047.9	1,240.8
Monolithic, Bipolar	1,350.4	936.2
Monotholic, Metal Oxide Silicon (MOS)	6,347.8	7,805.9
Monolithic, Other	469.7	185.5
Other	521.4	426.1
TRANSISTORS		
Signal Transistors (Dissipation rates of less than one watt)	138.6	159.6
Power Transistors (Dissipation rates of one watt or more)	311.7	317.2
DIODES AND RECTIFIERS		
Solar Cells and Other Photosensitive	80.5	123.7
Zener	47.9	48.1
Microwave	24.3	28.5
Thyristors	82.6	71.5
LEDs	82.5	89.9
Other	248.5	225.6
OTHER		
Chips, Dice and Wafers	1,060.4	1,058.3
Parts of Semiconductors	369.3	401.7
Watch and Clock Modules	na	na
TOTAL	12,183.5	13,118.6
Exports		
INTEGRATED CIRCUITS		
Monolithic, Linear	553.3	616.7
Monolithic, Bipolar	661.5	587.9
Monolithc, Metal Oxide Silicon (MOS)	2,992.4	5,170.8
Monolithic, Other	937.2	82.9
Hybrid	479.9	471.1
TRANSISTORS		
Signal Transistors (Dissipation rating of less than one watt)	77.8	68.6
Power Transistors (Dissipation rating of one watt or more)	140.7	143.8
DIODES AND RECTIFIERS		
Solar Cells and Other Photosensitive	97.8	92.4
Zener	34.1	20.3
Microwave	32.3	32.9
Thyristors	26.1	25.0
LEDs	26.8	36.0
Other	89.3	96.2
OTHER		
Chips, Dice, and Wafers	6,547.9	6,340.5
Parts for Diodes, Rectifiers, Transistors, ICs and Semiconductors	709.3	615.8
Other Related Electronic Components	75.4	102.7
Watch and Clock Modules	na	na
TOTAL	13,481.8	14,503.6

na—Not Available.
SOURCE: U.S. Department of Commerce.

term information such as disk drives and compact disks—they are able to erase old information and store new data in a flash. This technology will make possible smaller, powerful personal computers with a one-hundred fold increase in battery life by the end of the century. It is estimated that by 1995 worldwide sales of flash memory chips will exponentially increase to more than $1.4 billion, from less than $50 million in 1990.

Other Semiconductor Devices

Shipments of semiconductor devices, other than ICs and transistors, diodes and rectifiers, totaled $4.72 billion in 1991, up 1.3% from $4.66 billion in 1990, continuing a steady growth which started in 1987. Approximately 47% of the 1991 total was in shipments of chips and wafers for ICs and discrete semiconductors; another 30% was in shipments of other semiconductor parts, including headers, packages, and heat sinks.

Included in the remaining $1.1 billion of shipments were various light-sensitive devices, such as solar cells and photodiodes, thyristors and other semiconductor devices.

Imports and Exports of Solid State Products

Exports of solid state products increased 7.6% in 1991, to $14.5 billion, or 66% of total U.S. factory shipments of solid state products (Table 4-11). In 1990, exports of solid state products accounted for 63% of total shipments. In contrast, imports increased 7.7%, to $13.1 billion. The $1.4 billion trade surplus was a slight improvement over the 1990 trade deficit.

According to U.S. Government data, imports of integrated circuits, the largest import category, totaled $10.6 billion in 1991, an increase of 8.8% over 1990. IC exports reached $6.9 billion in 1991, recording 23% growth over 1990 exports of $5.6 billion. In 1991, there was a $3.7 billion trade deficit in ICs, an improvement over the $4.1 billion trade deficit in 1990. In 1991, trade in transistors reported $477 million in imports, a 6% increase over 1990, while exports were $212 million, a 3% drop over 1990. Imports of diodes and rectifiers totaled $585 million in 1991, a 3% increase over 1990. Exports of diodes and rectifiers reached $405 million in 1991, a 32% increase over such exports in 1990.

Chips, dice and wafers remained the largest single export category at $6.3 billion, down 3% over 1990, and posted a positive trade balance of $5.3 billion, down almost 4%, from $5.5 billion in 1990. Semiconductor parts, excluding chips, dice and wafers, provided a positive trade balance of $214 million in 1991, down 37%, from $340 million in 1990.

PASSIVE AND OTHER COMPONENTS

Sales of passive and other components totaled $55.97 billion, up 1.6% from 1990 sales of $55.09 billion (Table 4-1).

Passive and other components are electronic circuits that do not contribute to the electronic signal, as do tubes, and such solid state devices as semiconductors and integrated circuits. Passive and other components include capacitors; re-

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Factory Sales of Capacitors (Millions of Units and Dollars); United States, 1990-1991[1]

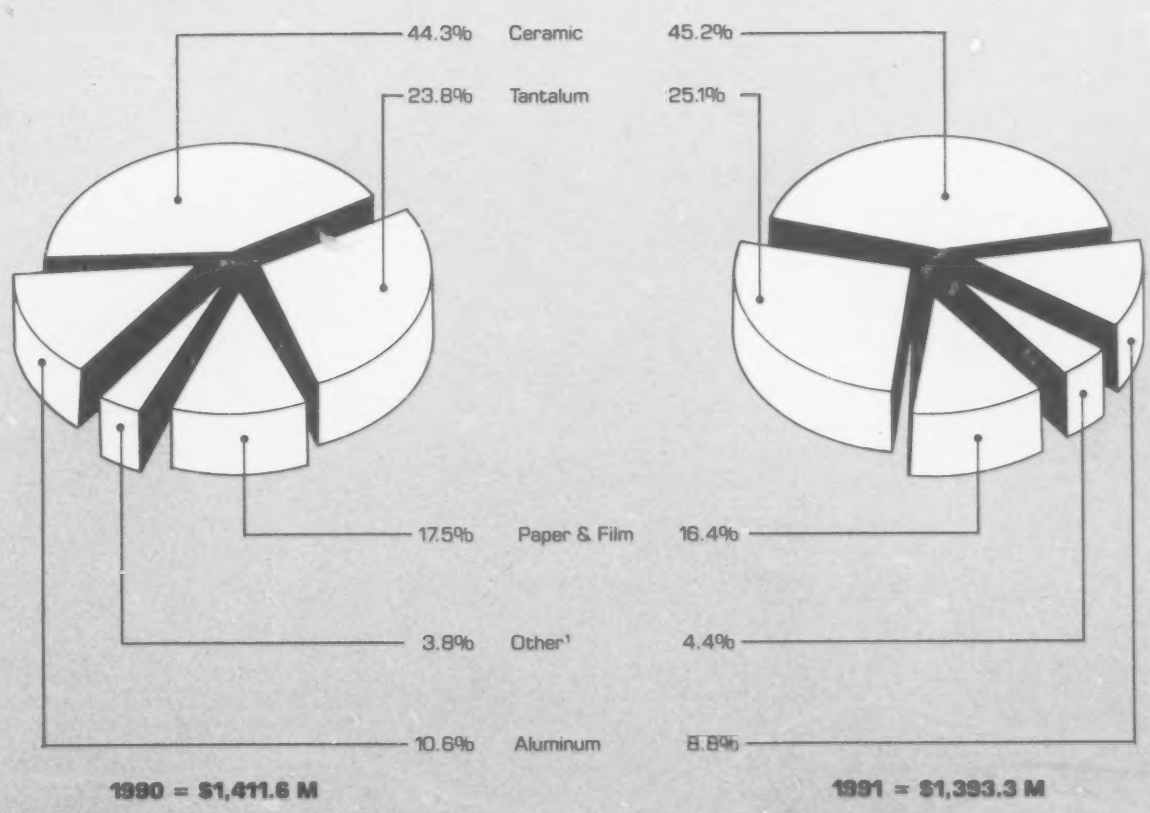
TABLE 4-12

	1990		1991	
	UNITS	DOLLARS	UNITS	DOLLARS
Paper & Film Dielectric	518.1	246.4	452.4	229.1
Tantalum Electrolytic	1,243.1	335.7	1,578.8	350.1
Aluminum Electrolytic	155.6	149.6	117.9	123.0
Ceramic Dielectric, Fixed	15,208.0	625.9	17,480.3	629.1
Other[2]	110.1	54.0	141.2	62.0
TOTAL	17,234.9	1,411.6	19,770.6	1,393.3

[1]Includes factory sales and imports by U.S. manufacturers.
[2]Other includes mica, all other fixed types, and variables.
SOURCE: EIA Marketing Services Department.

Distribution of Factory Sales of Capacitors by Type (%); United States, 1990-1991

FIGURE 4-C



[1]Other includes mica, all other fixed types, and variable.
SOURCE: Table 4-13

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sistors; passive networks; connectors; switches and relays; transformers and coils; quartz devices; filters; wire and cable; and TV and FM antennas and parts. For the most part, these components tune circuits, limit current flow, block the flow of direct current, and raise or lower voltages. To some degree, passive components have been replaced by integrated circuits—a trend that will continue slowing growth in the passive components market.

Capacitors

Factory sales of capacitors totaled 19.8 billion units, valued at $1.39 billion during 1991 (Table 4-12). A breakdown of dollar sales by type shows that ceramic capacitors accounted for 45.2% of dollar sales; tantalum capacitors represented 25.1% of sales; paper and film types accounted for 16.4% of sales and aluminum capacitors claimed 8.8% of total sales. All other types were placed at 4.4% of sales.

Of the nearly 19.8 billion unit sales of capacitors during 1991, 88.4% were ceramic types. Tantalum sales accounted for 8.0%; paper and film types represented 2.3%; while aluminum capacitors were at 0.6%. Unit sales of all other types represented about 0.7% of total sales.

In electronic applications, capacitors are used for filtering, tuning, coupling, decoupling, isolating, and storing of electrical energy. In 1991, the trend toward surface-mounted capacitors (as opposed to leaded, or capacitors with wire leads) continued and was spurred on by the computer, telecommunications and automotive industries. Disk drive and automotive OEMs require increasing numbers of surface-mounted tantalum chips.

Adoption of just-in-time (JIT) delivery by original equipment manufacturers (OEMs) is another trend that has affected the capacitor industry—forcing capacitor manufacturers to increase their inventories in order to deliver on a tight schedule. The latest technological trend in this area is to shrink multilayer ceramic capacitor electrodes in order to reduce the size of the components. This will pave the way for reduction of submicron layers, while stepping up production rates, increasing volumetric efficiencies and capacitances, and eliminating the need for conductive inks, according to industry experts.

The Electronic Outlook Corporation predicts that by 1995 40% of the $11 billion world consumption of capacitors will originate in the Far East. However, the United States is still the largest market for capacitors, especially for ceramic capacitors—roughly accounting for 45% of U.S. capacitor sales. The growth in this category may be as much as 15% for 1992, but some industry analysts have a more bleak outlook predicting market growth in the single digits. However, Frost and Sullivan forecasts the U.S. capacitor market to grow to $2.65 billion by 1993, with ceramics reaching $1.1 billion and tantalums reaching $625 million in 1993.

According to the U.S. Department of Commerce data, exports amounted to about $635.3 million in 1991, up about 11% over 1990. Exports exceeded imports by $89.9 million, a 128% increase in the capacitor trade surplus.

Factory Sales of Capacitors ($ Million); United States, 1975-1991[1] TABLE 4-13

YEAR	PAPER AND FILM	TANTALUM	ALUMINUM	MICA	CERAMIC	OTHER[4]	VARIABLE	TOTAL
1975	94	108	83	22	138	11	14	470
1976	129	131	111	24	185	12	16	608
1977	160	156	128	30	241	13	16	744
1978	205	188	151	[2]	289	43	20	896
1979	214	262	184	na	352	12	26	1,050
1980	208	470	178	na	407	14	22	1,299
1981	242	432	180	na	405	13	25	1,297
1982	233	348	158	na	398	12	20	1,169
1983	248	328	164	na	504	14	19	1,277
1984	314	413	189	na	670	16	17	1,619
1985	257	307	140	na	465	16	15	1,200
1986	263	302	131	na	493	15	19	1,223
1987	281	334	138	76[3]	546	14	22	1,411
1988	285	380	148	[2]	607	114	[2]	1,534
1989	281	350	147	[2]	631	127	[2]	1,536
1990	246	336	150	[2]	626	54	[2]	1,412
1991	229	350	123	[2]	629	62	[2]	1,393

Totals may differ from Table 4-13 because of rounding.
[1]Includes factory sales and imports by U.S. manufacturers.
[2]Combined with Other.
[3]Includes ceramic microwave, other ceramic and other aluminum.
[4]In 1988 and 1989, Other includes ceramic microwave, other ceramic, other aluminum, mica, all other fixed types and variables. From 1990 on, Other includes mica, all other fixed types and variables.
na-Not Available.
SOURCE: EIA Marketing Services Department

Resistors

During 1991, U.S. consumption of resistors, including chips, was 19.5 billion units, up 3.7% over 18.8 billion units in 1990. Dollar shipments reached an estimated $740.3 million in 1991, down 2.1% over comparable 1990 dollar sales of $756.5 million (Table 4-14). Resistor networks are treated separately (Table 4-15).

U.S. consumption of carbon-film resistors accounted for 29% of the discrete leaded resistor market in 1991, compared to 32% in 1990. Metal and other film resistors accounted for 16% in 1991, the same as 1990. Carbon composition resistors claimed a smaller share of the market—4% in 1991, as compared to 5% in 1990. Fixed wirewound resistors continued to have a small, 1.9% share of the market, and variables of different types, including potentiometers and trimmers, claimed a 5% share of the discrete leaded resistor market in 1991 and a 6% share in 1990.

The move toward surface-mounted resistors is gaining momentum, even though it has been inhibited by relatively high prices and a lack of standards. Standards have now been published, and eventually these will bring down the total cost-in-place of surface-mounted resistors. Increasing use of printed-circuit boards by the automotive industry will also speed movement toward chip resistors. (The Japanese have converted to chip resistors to a greater extent than the U.S. industry, and this undoubtedly presages some acceleration in the trend toward surface mounts in the U.S.).

Force-sensor technology, combining relatively low cost, ruggedness and noise immunity, is being melded in resistors for a variety of applications, including computer-controlled robot hands. Force-sensing resistors are two-layer devices, with one layer of polymer, upon which are affixed a set of interlocked metal strips; the other layer of plastic sheet is coated with a semiconducting ink.

Imports accounted for 45% of 1991 resistor consumption, measured in dollars—a slight increase from 45% in 1990. Imports also increased less than 2% in 1991, to $332.5 million. Exports of resistors declined 5% in 1991 to $242.8 million, resulting in a 22% increase in the deficit. Much of the imports,

Estimated Consumption of Resistors (Millions of Units and Dollars); United States, 1990-1991 — TABLE 4-14

RESISTOR TYPES	1990 UNITS	1990 $	1991 UNITS	1991 $
Fixed:				
Carbon Composition	895.3	31.3	751.7	26.6
Carbon Film	6,074.0	29.3	5,564.3	26.8
Metal and Other Film	3,076.3	84.5	3,020.9	83.0
Wirewound	390.3	108.4	368.9	104.6
Chips	7,326.2	68.7	8,793.6	82.5
Variable:				
Wirewound	52.5	45.0	49.9	42.5
Non-Wirewound	713.5	329.0	685.3	316.0
Other[1]	309.3	60.3	299.1	58.3
TOTAL	18,837.4	756.5	19,533.7	740.3

[1]Includes varistors, thermistors, etc.
SOURCE: EIA Marketing Services Department.

Sales of Passive Networks (Millions of Units and Dollars); United States, 1990-1991 — TABLE 4-15

DESCRIPTION	1990 UNITS	1990 $	1991 UNITS	1991 $
Resistor Thin Film	23.2	20.4	29.7	24.3
Resistor Thick Film:	828.2	159.6	799.6	156.0
Resistor	814.0	149.5	791.3	148.9
Resistor-Capacitor	14.2	10.1	8.3	7.1
TOTAL PASSIVE NETWORKS	851.4	180.0	829.3	180.3

SOURCE: EIA Marketing Services Department.

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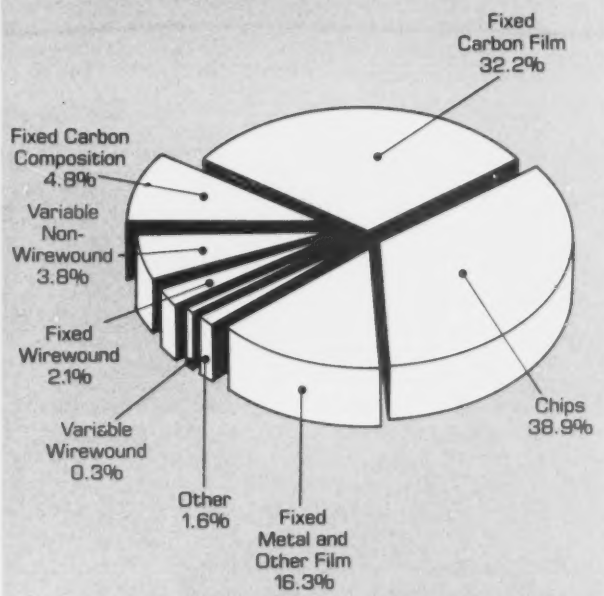
Distribution of Consumption of Resistors by Type (%); United States, 1990-1991 FIGURE 4-D



especially of carbon film and carbon composite resistors, comes from off-shore plants of U.S. manufacturers, mostly in Asia.

Resistors are a mature industry, with a low margin of profit. There has been some capital investment in recent years to improve quality and reduce costs, but prospects for much further investment or increased employment over the next few years are poor, except in connection with resistor networks.

Passive Networks

Sales of passive networks totaled 829.3 million units in 1991—valued at $180.3 million (Table 4-15). In units, this was a 2.6% decline over 1990, while dollar sales increased marginally by less than 1% from 1990.

Thick-film resistor networks made up 96% of the passive network units sold in 1991, the remaining were thin-film resistor networks. Of the thick-film resistor networks, about 1% included capacitors as well as resistors; the balance was resistors only.

Passive networks will continue to replace more individual resistors, while more and more of the resistive functions of electronic circuitry will be incorporated into integrated circuits.

Coils and Transformers

U.S. factory shipments of transformers and coils reached $962 million in 1991, according to Electronic Industries Association (EIA) estimates (Table 4-22), a 2.2% increase from 1990, ending the downward trend from the 1988 high of $1.18 billion.

Transformers are used to raise or lower AC voltages, or to insulate one AC circuit from another. Coils introduce inductance into AC circuits, which impedes the flow of AC current, and, with capacitors, can be used to tune such circuits.

Audio transformers, accounting for nearly 9% of the market, increased 2% in dollar volume in 1991. Shipments of plate and filament transformers, representing 15% of the market, also increased 2% in 1991. Pulse transformers, with 16% of the market, grew 2.2%. Toroidal windings, with 11% of the market, were up 2.2%. RF chokes and coils, together accounting for 10% of the market, followed the trend with a 2.1% increase in 1991.

Chief end users of transformers are manufacturers of stereo and other home electronic equipment, computers, telecommunications equipment, industrial and control instrumentation, and the military. The larger of these manufacturers often wind their own transformers, and they account for about 30% of U.S. production. Most other transformers are produced by small independent companies. With about 25% of U.S. production being exported, there was still a negative balance of trade of $1.05 billion in 1991, a decrease from $1.14 billion in 1990. The technical development efforts that exist with these products deal primarily with miniaturization, both of size and weight, in connection with surface mounting.

Connectors

U.S. factory shipments of electronic connectors are estimated to have reached $3.5 billion in 1991, an increase of 2.2% compared to 1990 (Table 4-19). Connectors represent 11% of the passive and other components' market in 1991—twice that of any other product.

Although sales in the merchant market for connectors have been sluggish in the U.S. and the world market, the brightest spot seems to be that of the niche market with an average growth rate of 66% in the U.S. and upwards of 195% in off-shore sales, according to *Electronic Business* magazine. The biggest opportunity for connector suppliers will be in telecommunications with the new plans for upgrading infrastructures in Eastern Europe and the Pacific Rim.

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Factory Sales of Accessory Parts of Televisions and FM Receivers (Thousands of Units and Dollars); United States, 1990-1991 TABLE 4-16

PRODUCT	1990		1991		% CHANGE	
	UNITS	$	UNITS	$	UNITS	$
Indoor Antennas	2,184	15,622	2,509	16,552	+14.9	+ 6.0
Outdoor Antennas	964	26,542	998	27,492	+ 3.5	+ 3.6
Antenna Amplifiers	421	12,141	431	12,336	+ 2.4	+ 1.6
Matching Transformers	3,227	1,933	3,347	2,056	+ 3.7	+ 6.4
Couplers and Splitters	3,937	4,065	4,525	4,579	+14.9	+12.6
Frequency Separators	425	998	474	1,069	+11.5	+ 7.1
TOTAL	11,158	61,301	12,284	64,084	+10.1	+ 4.5

SOURCE: EIA Marketing Services Department.

Printed-circuit board connectors, mostly used with computers, continued as the leading type of connector, with 28% of the market—virtually unchanged since the high of 32% in 1988. Market shares for other types remained virtually the same. Cylindrical connectors, used mainly in defense and transportation equipment, maintained about 14%. Rack and panel connectors, also used in defense and transportation, were also fairly steady at about 14%. Planar connectors and hermetic sealed connectors held their shares, 8% and 3%, respectively. The high cost of fiber-optic connectors continues to limit this type to a small percentage of the market. Other types of connectors accounted for 15% of the total connector market, while parts for connectors accounted for 5%.

As circuitry speed increases and product size decreases, the industry will need to produce smaller connectors with more contacts in less space. While high cost has restrained growth for fiber optics in the commercial sector, the military has chosen the product for its superior technical advantages. With continued price erosion, the private sector is beginning to take advantage of fiber optics immunity to electromagnetic and radio frequency interference, its light weight, and its greater speed and bandwidth.

The forecast for the entire line of connectors is rather optimistic. Leading Edge, one market observer, reports that fiber-optic, printed-circuit, and special-purpose connectors will have the greater demand through the end of the decade. Fiber-optic connectors are expected to hit $500 million in U.S. shipments by the year 2000. The second and third largest areas of growth, printed-circuit and special-purpose connectors, respectively, will together account for almost $3.0 billion of a $6.8 billion market in the U.S. by the end of the century.

Exports accounted for 4% of 1991 and 1990 shipments. Imports increased 8% in 1991, reaching $473.8 million. The resulting trade deficit in 1991 was $335.6 million, a 10% increase.

Switches and Relays

Factory shipments of switches totaled an estimated $603 million in 1991, up 2.2% from 1990 shipments of nearly $590 million (Table 4-17).

While switches are essentially very simple controls that translate manual motion to the opening and closing of elec-

Factory Shipments of Switches ($ Million); United States, 1982-1991 TABLE 4-17

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Toggle	89.0	104.3	98.2	77.1	86.7	93.9	97.6	101.0	94.6	96.7
Slide	58.5	69.1	67.6	62.8	66.4	75.9	83.1	84.7	74.2	75.9
Rotary	72.5	64.8	83.1	73.8	66.5	77.0	68.4	55.8	51.3	52.5
Keyboard	22.0	33.1	48.9	36.5	39.6	45.9	38.7	32.2	33.2	34.0
Pushbutton	38.5	47.1	96.2	72.2	48.0	92.6	50.9	52.9	41.8	42.7
Snap-Action	30.7	14.1	13.1	21.4	10.0	11.8	13.5	7.1	7.0	7.2
Thumbwheel					45.0	42.0	29.1	20.8	21.9	22.3
Other Switches	134.9	179.4	140.6	232.8	174.6	252.9	243.3	289.9	265.6	271.4
TOTAL	446.1	511.9	547.7	576.6	536.8	692.0	624.6	644.4	589.6	602.6

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
SOURCE: U.S. Department of Commerce.

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tronic (and electrical) circuits, there are dozens of different types, with pushbutton, rotary, slide, and toggle types accounting for 44% of 1991 shipments. Shipments of the different switch types were essentially the same in 1991 as in 1990. Market shares, while varying considerably over time, were somewhat stable from 1990 to 1991, changing a few tenths of a percent. There has been no recent period during which the total dollar sales of switches has increased in two consecutive years.

As switch suppliers become more and more integrated with their end-users, design and manufacturing of switching devices will increasingly be forced to employ methods such as just-in-time delivery, CAD/CAM, and standardization, to reduce lead-time and increase quality. Industry experts believe

Factory Shipments of Electronic Relays ($ Million); United States, 1982-1991 TABLE 4-18

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
General purpose										
over 100 MW	42.8	49.7	241.9	244.5	210.0	187.4	146.5	123.4	83.8	81.5
0-100 MW					10.0	8.7	9.2	23.0	20.6	20.1
Solid State					21.8	11.9	15.6	16.7	20.1	19.6
Sensitive relays (through 100 MW)	10.7	na	na	na	na	na	na	na	na	na
Crystal can types	27.2	43.0	22.3	23.6	67.1	67.4	73.5	78.4	61.2	59.5
Reed relays	[1]	54.5[2]	69.6	130.5	86.3	86.2	78.4	79.1	72.1	70.2
Miniature printed circuit mounted (sealed and unsealed)	na	19.0	27.9	36.4	18.8	22.3	26.3	21.3	18.3	17.8
Timing relays	na	17.9	31.3	41.1	47.8	55.8	56.6	73.7	77.5	75.4
All other relays and parts	201.3	111.8	158.7	154.4	126.6	156.6	100.8	113.9	118.1	114.9
TOTAL	282.0	295.9	551.7	630.5	588.4	596.3	506.9	529.5	471.7	459.0

r-Revised.
e-Estimated by EIA Marketing Services Department.
na-Not available.
[1]Included in "all other relays and parts."
[2]Includes dry reed only.
SOURCE: U.S. Department of Commerce.

Factory Shipments of Electronic Connectors ($ Million); United States, 1982-1991 TABLE 4-19

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Coaxial	214.4	211.2	256.5	331.9	347.4	470.4	454.3	405.1	392.0	400.6
Cylindrical	387.6	414.7	466.0	452.7	463.4	573.5	578.7	540.3	489.9	500.7
Rack and Panel	385.2	420.1	483.8	360.9	437.4	499.8	513.6	537.3	487.6	498.3
Printed Circuit	444.4	598.0	724.0	728.8	728.1	998.3	1,149.8	986.4	969.0	990.3
Hermetic Sealed	90.0	152.5	177.1	168.8	152.1	174.5	126.9	129.3	115.1	117.6
Planar Cable[1]	208.8	263.2	310.0	217.8	212.6	229.5	247.3	244.5	282.9	289.1
Fiber Optic	na	na	*	*	5.8	8.1	6.8	17.6	26.9	27.5
Other	352.1	434.5	660.6	440.2	495.0	508.9	507.9	557.1	499.9	510.9
Parts for Connectors	65.7	91.8	122.4	199.7	183.9	166.2	162.5	175.3	167.5	171.2
TOTAL	2,148.2	2,586.0	3,200.4	2,900.8	3,025.7	3,629.2	3,747.8	3,592.7	3,430.8	3,506.2

[1]Includes fiber optic connectors in 1984 and 1985.
e-Estimated by EIA Marketing Services Department.
r-Revised.
na-Not available.
*Included in Planar Cable.
SOURCE: U.S. Department of Commerce.

Factory Shipments of Piezoelectric Devices ($ Millions); United States, 1982-1991 TABLE 4-20

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Oscillator Crystals	95.3	71.9	120.5	86.3	99.4	105.3	117.0	84.6	74.1	75.7
Crystal Oscillators	106.8	120.9	96.9	121.8	147.4	186.3	155.9	89.5	85.8	87.7
Crystal Filters	47.2	42.4	62.9	55.6	56.6	68.6	77.9	48.0	38.3	39.2
Crystal Blanks	16.9	21.7	59.9	74.5	15.9	34.6	30.2	25.7	34.1	34.9
TOTAL	266.2	256.9	340.2	338.2	319.3	394.8	381.0	247.7	232.4	237.5

e-Estimated by EIA Marketing Services Department.
r-Revised.
SOURCE: U.S. Department of Commerce.

that as the need for longer life, higher quality, and protection against harsh environments become mandatory in switches, there will be a need to develop new solutions for the increasingly demanding market.

It is estimated that total U.S. shipments (including imports) of switches will reach $1.4 billion by 1996, according to Venture Development Corporation. This increase will be driven by higher demand, which will off-set the decreasing cost of switches. According to EIA estimates, factory shipments of electronic relays totaled $459 million in 1991, a 2.7% decrease from 1990 sales of nearly $472 million (Table 4-18).

In a similar manner to switches, relays are devices for opening and closing electronic (and electrical) circuits, and are mainly electromechanical. However, while switches are activated manually, relays are activated by such means as: voltages created in testing, by the closing of switches or other relays, and by overloads.

General-purpose electromechanical relays account for 26% of the total in 1991. Timing relays, miniature relays mounted on printed-circuit boards and crystal can types account for 33%, while reed relays claimed 15% of total sales. Other types of relays, and parts, make up the balance.

In many respects, electromechanical relays would seem to represent an outdated technology that should be replaced by solid-state devices. However, there has been continued improvement in electromechanical relays—in miniaturization and reliability—and there has been a steady lowering of costs. One area of development in relays is in the low-signal segment of the PCB relay market, which is the most technologically advanced of the commercial electromechanical relays. The demand for this type of relays is driven by emerging world standards, advances in materials for contacts and housings, power-efficiency improvements in coil and armature design, and up-to-date, automated manufacturing techniques for precision and quality assembly. The largest application has been in telecommunications, followed by manufacturing of computers, computer peripherals, office automation equipment, consumer electronics, security systems, and industrial controls, according to *Electronic Buyers' News*.

These trends have continuously delayed the long-expected shift to solid state. Solid state relays in 1991 account for only about 4% of the total, about the same share they have held for the previous two years. One critical problem with solid state relays has been power isolation. Solid state relay pricing is fairly stable in 1992, but it is expected to decline in the future. Top relay users (manufacturers of PBX, computers, disc drives, and printers) are all demanding miniaturization, or high-density packaging, low power, and high reliability.

Filters

U.S. factory shipments of filters totaled an estimated $188 million in 1991, representing a 22% gain from 1990 (Table 4-21).

Filters are used to prevent electronic equipment from radiating electrical waves which have the potential to interfere with other equipment. For example, they are used with computers to prevent computers from interfering with television sets. They can also be used with electronic equipment to suppress interference, such as surge protectors. They are increasingly being used in communications and by the military.

Filters can be quartz devices, but most are based on properly designed capacitors. Radio-frequency interference (RFI) control filters and electro-magnetic interference (EMI) control filters are the most common types. RFI/EMI control filters accounted for 88% of all U.S.-manufactured filters (measured in dollars), and grew 2.2% in 1991. Microwave filters, a relatively new type of filter which is increasingly being used with TV and communications equipment and in many military applications to keep out unwanted frequencies, accounted for about 12% of all filter sales, staying virtually flat in 1991, with sales of $22.5 million.

Quartz Devices

U.S. factory shipments of quartz devices are estimated at almost $238 million in 1991, up 2.2% compared with 1990 shipments (Table 4-20).

Quartz devices take advantage of the fact that a quartz crystal will resonate at a fixed frequency, the exact frequency is dependent on its size and how it is cut (just as a diamond will reflect different wave lengths of light, depending on how it is cut). Quartz crystals are used in expensive clocks to establish frequency (in inexpensive watches, silicon dioxide crystals are used for this purpose); they are used to generate a reference frequency in various types of instruments; they control the operating frequency used by radio and TV trans-

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Factory Shipments of Filters ($ Million); United States, 1982-1991 TABLE 4-21

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Filters, except microwave:										
Mechanical	14.2	3.7	1.5	1.9	1.3	13.2	12.9	159.4	161.4	165.0
RFI/EMI Control	87.6	110.1	123.9	112.1	134.9	162.0	130.9			
Feed-thru and Bypass Capacitors	9.0	21.6	24.1	7.0	8.1	na	na	na	na	na
Electronic Wave	31.5	31.1	82.7	57.1	65.7	57.3	46.0	23.8	22.0	22.5
TOTAL	142.3	166.5	232.2	178.1	210.0	232.5	189.8	183.2	183.5	187.5

e-Estimated by EIA Marketing Services Department.
na-not available
r-Revised.
SOURCE: U.S. Department of Commerce.

mitters, and by two-way radio sets and cellular telephones; they are used as clocks in all personal computers; and they are used extensively by the military.

Oscillator crystals are the cut and polished crystals. Factory shipments of oscillator crystals grew 2.2% in 1991. Crystal oscillators are the crystals, plus associated circuitry and they accounted for 37% of quartz device shipments, recording a sales gain of 2.2% in 1991. Crystal filters, which accounted for 17% of quartz device shipments, are filter circuits employing quartz crystals to block out unwanted frequencies. They experienced a 2.3% growth in sales in 1991. Crystal blanks, 15% of quartz device sales, are the uncut crystals. Crystal blanks also registered a 2.3% increase in sales in 1991.

Wire and Cable

Shipments of electronic wire and cable totaled $1.65 billion in 1991, down 3.7% over 1990 (Table 4-23). Single hook-up wire accounted for 19% of the wire and cable market in 1991, while the industry experienced a 3.8% decline. Antenna lead-in wire shipments declined 3.7%, and represented 16% of the market. Flexible coaxial cable, with 15% of the market, recorded a 3.8% decline in 1991 shipments, while rigid and semiflexible cable, also at 15% of the market, reported a 3.7% decline. Flat and ribbon multiconductor cable, with 6% of the market, recorded a 3.7% decrease. Other multiconductor cable, with a 29% share, also declined 3.7%.

Factory Shipments of Coils and Transformers ($Million); United States, 1982-1991 TABLE 4-22

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Audio Transformers	130.9	164.1	263.4	290.3	139.7	166.7	115.1	107.9	90.4	92.4
Low Frequency Chokes	26.2	27.0	30.0	29.9	34.3	33.9	55.0	51.4	39.6	40.5
Plate and Filament Transformers	187.1	196.0	192.5	186.1	174.1	188.4	191.4	175.9	139.7	142.7
Pulse Transformers, Computer and Other	98.5	88.2	113.5	124.4	143.1	160.4	174.5	156.3	148.7	152.0
RF Chokes	32.2	36.2	45.5	39.4	37.9	49.7	54.1	53.0	43.4	44.3
RF Coils	38.4	36.1	51.4	48.7	46.8	50.9	54.9	52.3	50.4	51.5
IF Transformers	19.9	15.6	19.0	20.9	16.2	14.2	14.7	14.6	14.9	15.2
TV Transformers & Reactors	35.1	46.8	35.0	38.9	38.2	35.6	32.4	29.0	22.6	23.1
Toroidal Windings	81.0	86.3	99.7	100.1	93.7	102.1	102.1	105.0	103.5	105.8
Other	192.7	269.2	205.1	300.3	317.7	347.0	389.0	354.4	287.8	294.1
TOTAL	842.0	965.5	1,055.1	1,179.0	1,041.7	1,148.9	1,183.2	1,099.7	940.9	961.6

e-Estimated by EIA Marketing Services Department.
r-Revised.
SOURCE: U.S. Department of Commerce.

Factory Shipments of Electronic Wire and Cable ($ Million); United States, 1982-1991 TABLE 4-23

	1982	1983	1984	1985	1986	1987	1988	1989r	1990r	1991e
Coaxial cable, armored or unarmored:										
Rigid and semiflexible	374.1	335.0	337.5	240.4	234.3	264.8	219.3	277.7	252.5	243.2
Flexible[1]	209.3	264.6	275.7	305.0	263.9	335.1	315.2	269.8	259.5	249.9
Antenna lead-in wire[2]	25.2	49.8	61.6	56.9	66.0	43.0	167.5	288.0	275.2	265.0
Hook-up wire, single conductor, shielded and nonshielded	222.6	245.7	291.7	274.4	275.3	354.4	332.4	331.7	324.3	312.3
Multiconductor, shielded and nonshielded:										
Flat and ribbon cable	54.8	80.3	93.4	73.9	78.2	86.0	102.4	96.9	98.9	95.2
Other	417.5	410.1	553.5	524.7	491.3	578.3	635.2	604.4	502.2	486.5
TOTAL	1,303.5	1,385.5	1,613.4	1,475.3	1,409.0	1,661.6	1,772.0	1,868.5	1,715.5	1,652.1

e-Estimated by EIA Marketing Services Department.
r-Revised.
[1]Includes CATV/broadcast coaxial in 1985.
[2]Includes CATV/broadcast coaxial subsequent to 1985.
SOURCE: U.S. Department of Commerce.

Industry experts have expressed relatively more optimistic outlooks for this industry. It is estimated that shipments will increase 4.9% annually through 1994, but will be off-set by increasing competition from fiber optic cable, satellite transmission and other alternative technologies, according to the Freedonia Group. Another market researcher, Frost & Sullivan, predicts that with an adjustment for expected inflation, the market will grow more than 10% per year through 1995.

The latest trend in this category is toward large volume, bulk production for large customers, which has prompted automation utilizing computer integrated manufacturing (CIM) and, for the smaller producers, flexible manufacturing systems. The new products are using such technologies as "low vertical profile" flame retardant optical fiber; ultraviolet curable coatings for optical fibers; ceramic superconducting wire, silane copolymer technology; CSL Light Splice system; and SuperLite hybrid cables.

TV and FM Accessory Parts

Factory sales of accessories for TV and FM receivers in 1991 grew 4.5% in dollar terms, to $64.1 million. Unit sales also rose, but at a higher rate than dollar sales—reflecting lower prices, to a level of 12.3 million units (Table 4-16). Indoor antennas saw unit sales grow 14.9%, while dollar sales grew only 6.0%. Couplers and splitters recorded unit growth of 14.9% in 1991, reaching 4.5 million units, while dollar sales increased 12.6% to nearly $4.6 billion.

Printed-Circuit Boards (PCBs)

According to the Institute for Interconnecting and Packaging Electronic Circuits, U.S. production of rigid and flexible printed-wiring boards decreased from $5.4 billion in 1990, to $5.2 billion in 1991. At the same time, total U.S. production of independent assembly companies increased from $4.4 billion in 1990, to nearly $5 billion in 1991. U.S. imports of printed-circuit boards (PCBs) reached $1.9 billion in 1991, up 90%. Exports totaled $1.6 billion in 1991, a decrease of 17% from export sales in 1990. Consequently, 1991 recorded a trade deficit of $323.6 billion, compared to a trade surplus of $889.0 billion in 1990.

One industry observer projects that worldwide shipments of printed-circuit boards will climb to $31.9 billion by the year 2000. Business Communications Company, a market research firm, estimates U.S. shipment of printed-circuit boards in 1995 to increase by less than half of the 1990 sales to $8.6 billion, and by the end of the century to have more than doubled to $12.7 billion. A large portion of this market is dominated by rigid PCBs—single-sided, double-sided or multilayered.

Printed-circuit boards are the boards on which electronic components are mounted, and which have traces—the wiring pathways that interconnect the components—printed on the boards. They are used in all personal computers, and are widely used in all other computers, telecommunications equipment, instrumentation, and in the automotive market. Relatively small independent companies account for more than half of printed-circuit board production. About 10% of all production, as measured in dollars, is in single-sided boards. The balance is divided almost evenly between double-sided and multilayer boards, with multilayered boards growing at a slightly faster rate than double-sided boards.

The predominant technological developments are trends toward miniaturization and finer lines. As surface-mounted technology (SMT) becomes more widely used, it also leads toward the elimination of through-holes which are needed for components with leads but not needed when components are soldered directly to copper traces. Other technological advances are aimed at finding better plastic materials for printed-circuits to reduce moisture absorption. As traditional

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PCB materials begin to diminish advances made in integrated circuitry. new materials. which have a higher degree of flatness and a lower dielectric constant. are being sought by PCB manufacturers.

Competition from Japan and Taiwan has caused printed-circuit board prices to drop. and in an effort to reduce costs. many U.S. manufacturers have moved production offshore.

Imports and Exports of Passive and Other Components

U.S. exports of passive and other components increased 4.5% in 1991. reaching $7.2 billion. TV tuners. reception equipment. and parts of phono and tape players combined was the largest export category. accounting for 28% of all exports. Printed-circuit boards were the second largest export category in 1991. decreasing 17% to $1.58 billion. Wire and cable. the third largest category in 1991. increased by 18% to $1.5 billion in 1991.

Total U.S. imports of passive and other components totaled $9.4 billion in 1991. up 27% from 1990. As in exports. TV tuners. reception equipment. and parts of phono and tape players combined was the largest import category. accounting for 22% of all imports. This category recorded imports of $2 billion in 1991. an increase of more than 8% over 1990. The largest decline was posted by transformers. rectifiers. rectifying apparatus and parts. dropping 3.6%. to $1.3 billion.

Despite the positive performance in exports during 1991. the trade deficit for passive and other components totaled $2.1 billion. a decrease of 2.8% from 1990's deficit of $2.2 billion. Wire and cable recorded the largest positive balance of trade in 1991. with a surplus of $397.4 million. Capacitors were the only other category to record a surplus. with $89.9 million. Printed-circuit boards recorded a surplus of $31.4 million in 1990. and a deficit of $326.3 million in 1991.

Balance of Trade for Passive and Other Components ($ Million); United States, 1990-1991 TABLE 4-24

	IMPORTS		EXPORTS		BALANCE OF TRADE	
	1990r	1991	1990r	1991	1990r	1991
Transformers, Rectifiers Rectifying Apparatus and Parts	1,332.0	1,283.9	194.2	238.4	−1,137.8	−1,045.5
Loudspeakers, Microphones and Amplifying Equipment	248.2	266.8	119.0	134.9	−129.2	−131.9
TV Tuners, Reception Equipment, and Parts of Phono and Tape Players	1,876.9	2,031.2	1,825.5	2,022.8	−51.4	−8.4
Capacitors	532.5	545.4	571.5	635.3	+39.0	+89.9
Switches and Relays	523.3	525.4	311.3	341.7	−212.0	−183.7
Connectors	439.1	473.8	134.0	138.2	−305.1	−335.6
Printed Circuit Boards	1,859.6	1,903.9	1,891.0	1,577.6	+31.4	−326.3
Resistors	343.7	336.2	251.5	242.8	−92.2	−93.4
Wire and Cable	1,145.9	1,101.7	1,271.0	1,499.1	+125.1	+397.4
Indicator Panels	426.3	489.5	163.0	225.0	−263.3	−264.5
Other	404.0	422.6	204.3	191.5	−199.7	−231.1
TOTAL	9,131.5	9,380.4	6,936.3	7,247.3	−2,195.2	−2,133.1

r-The 1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and achieve compatability between the trade data and domestic factory sales data.
SOURCE: U.S. Department of Commerce.

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GOVERNMENT DIVISION
PRODUCTS AND SERVICES

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The EIA "Ten-Year Forecast of Defense Electronic Opportunities (FYs 1992-2001)," a 500-page conference report, features the EIA 27th Annual Ten-Year Forecast of DoD and NASA. Included in the publication are ratings for over 500 DoD/NASA programs and a briefing on Defense Electronics in Europe. In addition, analyses and forecasts of specific markets for the Departments of Energy and Transportation, Military Night Vision and Electro-optics market, and the Airborne, Reconnaissance, Surveillance, and Verification (ARSV) market are presented.

Price: $150 (EIA Government Division members), $300 (non-members).
Contact: Kelly Murphy (202) 457-8748.

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Contact: Mary Lamb (202) 457-4943.

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Contact: Simone Smith (202) 457-4999.

5 Government Electronics

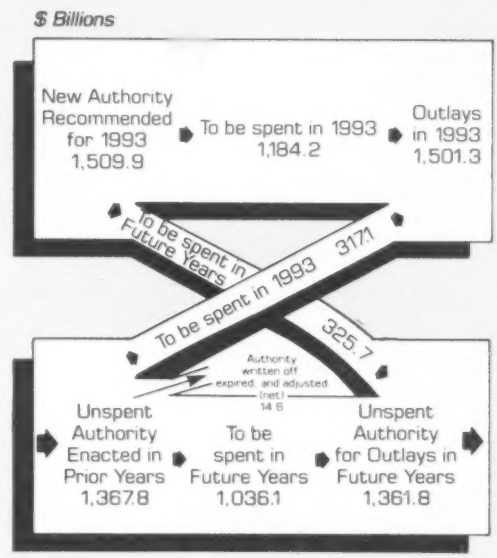
The Fiscal Year 1993 United States Budget submitted by President George Bush has a total outlay of $1.51 trillion (Table 5-1, Figure 5-A). The overall budget increased 2.8% for the last fiscal year, due mostly to the restrictions imposed by the 1990 Budget Agreement. The Administration sought increases for Education, Energy, Justice, State, Treasury and Veterans Affairs. Decreases were sought for Agriculture, Commerce, Defense, HUD, Interior and Transportation.

In the short term, the President's growth agenda calls for a reduction in the excessive personal income tax withholding by an average of $345 per year; new investments and incentives to stimulate job creating investment; and a proposed capital gains incentive that reduces the tax on long-term gains to 15.4%. There are new real estate incentives, and to invest in the future the President outlined a record investment in federal research and development ($76.6 billion). There are also initiatives to reform health care.

On the international scene, the Administration looks for opportunities to expand exports in a regime of free and fair trade. These include GATT negotiations and a continued bilateral effort to open markets for U.S. exports. The FY 1993 Budget reflects renewed efforts to bring the growth of the federal budget and deficit under control, and to reduce the drain on savings. These include complete elimination of 246 programs and over 4000 projects whose funding is not sufficiently justified. There is also a further reduction in defense spending of $50.4 billion by 1997, bringing the total real defense decrease to 29% since 1989.

The prolonged recession has made the economy the number one concern for most United States citizens. Along this

Relationship of Budget Authority to Outlays—1993 FIGURE 5-A


$ Billions
New Authority Recommended for 1993 1,509.9
To be spent in 1993 1,184.2
Outlays in 1993 1,501.3
To be spent in Future Years 317.1
To be spent in 1993 325.7
Authority written off, expired, and adjusted (net) 14.6
Unspent Authority Enacted in Prior Years 1,367.8
To be spent in Future Years 1,036.1
Unspent Authority for Outlays in Future Years 1,361.8

SOURCE: Budget of the United States Government, Fiscal Year 1993.

Receipts, Outlays, Deficit/Surplus Under the President's Proposed Policy ($ Billions) TABLE 5-1

	1991	1992	1993	1994	1995	1996	1997
Receipts	1,054.3	1,075.7	1,164.8	1,263.4	1,343.5	1,427.5	1,501.8
Outlays	1,323.0	1,475.1	1,516.7	1,474.8	1,535.5	1,607.5	1,683.6
Surplus or Deficit	−268.7	−399.4	−351.9	−211.4	−192.1	−180.0	−181.8

SOURCE: Budget of the United States Government, Fiscal Year 1993.

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National Defense Topline[1] (Current $ Billions) TABLE 5-2

	1992	1993	1994	1995	1996	1997
BUDGET AUTHORITY						
DoD 051	270.9	267.6	267.8	269.9	270.4	274.6
DoE & Other	12.9	13.3	13.9	14.5	15.3	16.0
TOTAL 050	283.8	280.9	281.7	284.4	285.7	290.6
OUTLAYS						
DoD 051	282.6	272.8	267.4	267.9	270.9	273.6
DoE & Other	12.6	13.1	13.6	14.1	14.9	15.5
TOTAL 050	295.2	285.9	281.0	282.0	285.8	289.1

[1]Excludes Cost of Desert Shield/Desert Storm
SOURCE: Secretary of Defense Press Briefing, January 29, 1992.

line, the President calls for prompt Congressional action on the agenda for growth. In the budget message of the President to Congress on January 29, 1992, he stated that the United States must not only get the economy moving again in the short term, but it must also put America firmly on the path to long term economic growth and competitiveness. In his State of the Union message, he reemphasized the importance of stimulating the investment necessary to create jobs. He maintained that the U.S. must address the problems related to real estate and health care, and eliminate unnecessary federal regulation. Moreover, these objectives must be achieved in a way that brings the deficit under control. He followed with specific incentives for investment, savings and home ownership, tax relief for families, investments in the future, and proposals for reform—ranging from health to education.

FISCAL YEAR 1993 DEFENSE BUDGET

In brief, the Department of Defense (DoD) intends to slow the pace of modernization and cut the strategic nuclear arsenal, while maintaining the essential forces. The President calls for a new approach in the way the DoD buys major weapons systems and keeps its forces modern, while maintaining a military capable of responding to regional contingencies. The budget's FY 1992-1997 program includes changes to the U.S. strategic nuclear program, marking a shift away from a relationship of nuclear confrontation with the republics of the former Soviet Union.

The Administration is seeking $267.6 billion in DoD budget authority for the fiscal year 1993, $9.9 billion below the budget passed by Congress for FY 1992, with a decline of 7% in real terms, adjusted for inflation. The cuts in the defense budget go beyond the steep cuts already undertaken—amounting to a decline in budget authority of over one-third in real terms since 1985 (see Table 5-2).

The FY 1993 budget submission also cuts the Department's six year defense plan, for FY 1992-1997, by $63.8 billion, compared to the six year plan presented last year for the same period. That total includes $50.4 billion in cuts to the defense program and $13.4 billion in adjustments required under the budget summit agreement, based on changes in the 1991 rate of inflation. The budget proposes FY 1993 outlays of $272.8 billion, $9.8 billion below FY 1992. Outlays for FY 1992-1997 would be cut by $27.4 billion over last year's defense plan. For major systems in the FY 1993 budget see Table 5-3.

Defense Secretary Dick Cheney said, "The national security picture for the United States has changed substantially since last year. The disintegration of the Soviet Union has reduced the threat to U.S. interests and eliminated the urgency for producing several advanced weapons systems." According to Cheney, many of the developments were anticipated in the regional defense strategy first announced by President Bush in August of 1990.

"We can now afford to be more deliberate in the pace at which we modernize our armed forces. And the emergence of democratically inspired reformers in the republics of the former Soviet Union presents an historic opportunity to make further reductions in the world's strategic nuclear arsenal, as the President proposed in his State of the Union (January, 1992) message," he said.

Major Systems in the FY 1993 Department of Defense Budget ($ Billions) TABLE 5-3

	FY 1993
Strategic Defense Initiative	5.4
Advanced Tactical Fighter (F-22)	2.2
DDG-51 Destroyer	3.5
C-17 Aircraft	2.9
MILSTAR Satellite	1.3
UH-60 Helicopter	0.4
B-2 Bomber	4.0
F/A-18 Aircraft	3.1
Trident II Missiles	1.1
Joint Stars (E-8B) Aircraft	0.7
RAH-66 Comanche Helicopter	0.4

SOURCE: Secretary of Defense Press Briefing, January 29, 1992.

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Secretary Cheney also indicated that he will stop the Air Force's B-2 stealth bomber program after the 20th aircraft is produced, terminate the Midgetman small intercontinental ballistic missile program, and stop production of the advanced cruise missile at 640, instead of the 1,000 originally planned. These strategic program adjustments alone will save nearly $20 billion through FY 1997.

Furthermore, Cheney stated that the DoD would not seek additional production of the Navy's heavier warhead for its submarine launched ballistic missiles, eliminating the need for the Department of Energy to resume production of the W-88 warhead for Trident submarine missiles.

While these are unilateral steps, the President also called upon President Yeltsin to curtail his own strategic modernization programs.

Further Strategic Force Cuts

The DoD's FY 1992-1997 program carries forward the deep reductions in nuclear weapons called for by the START agreement and President Bush's September 1991 nuclear initiative. The program also reflects the additional strategic nuclear force changes proposed in the President's 1992 State of the Union address.

In September of 1991, the President directed the Pentagon to cancel the rail garrison basing mode for the Peacekeeper ICBM, the SRAM-II short range attack missile, and the mobile version of the small ICBM. In his January 1992 State of the Union speech, he proposed to further reduce the U.S. strategic nuclear force if Russia takes similar steps.

Under the President's early 1992 proposal, the U.S. would eliminate its Peacekeeper missiles; reduce the number of warheads on its Minuteman III missiles to one (from the current three); reduce by a third the number of warheads on its ballistic missile submarines; and shift many of its strategic bombers to primarily conventional roles. These actions would be undertaken if Russia eliminates all its land based, multiple warhead ballistic missiles and reduces its strategic nuclear force to a level consistent with the absence of any threat from the West.

The growing proliferation of ballistic missile capability and weapons of mass destruction makes the funding of the President's program for global protection against limited strikes a high priority for strategic programs. Funding for the Strategic Defense Initiative remains a top priority, with a request for $5.4 billion in budget authority for FY 1993, compared to the FY 1992 total of $4.1 billion.

Defense Budget Trends

From FY 1993 through FY 1997, the DoD budget authority will decline, in real terms, an average of 4% each year. By FY 1997, the cumulative real decline in budget authority since FY 1985 — the year of peak defense spending—will total 37%. Budget authority for FY 1997, adjusted for inflation, will produce about the same buying power as the 1960 defense budget and only slightly more than that of the post-Vietnam drawdown defense budgets of 1974-76 (Tables 5-4 and 5-5).

Defense outlays as a share of the U.S. gross national product are expected to fall to 3.4% in FY 1997, well below any period since pre-World War II. In FY 1997, defense outlays should be down to 16% of total federal outlays (Figure 5-B).

While defense spending has been shrinking since 1985, domestic spending has been growing — going up by about the same rate at which defense spending is going down. By FY 1997, the cumulative real decline in defense outlays since FY 1985 will be 26%. Mandatory federal spending will increase about 33% in real terms over the same period, and domestic discretionary outlays will increase about 8%.

New Approach to Acquisition

The disintegration of the Soviet Union has reduced the military threat to U.S. interests, and therefore, the need to produce advanced weapons systems is less urgent. The DoD can afford to take more time in developing and evaluating new technologies before making decisions on weapons production. With more reliance on its research and development efforts, the DoD can preserve the technological capability to quickly

DOD Budget Authority by Title[1]
($ Billions)

TABLE 5-4

	1990	1991	1992	1993
Military Personnel	78.6	78.4	78.3	77.1
O&M	87.0	85.3	86.4	84.5
Procurement	81.4	66.5	58.5	54.4
RDT&E	36.5	36.1	36.9	38.8
Military Construction	5.1	5.2	4.9	6.2
Family Housing	3.1	3.3	3.6	4.0
Revolving Funds Transfer	–	–	–	2.0
All Other	-0.7	1.2	2.3	0.6
GRAND TOTAL	291.0	276.0	270.9	267.6

[1]Excludes Cost of Desert Shield/Desert Storm.
SOURCE: Secretary of Defense Press Briefing, January 29, 1992.

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DOD Budget Authority by Service[1]
($ Billions)

TABLE 5-5

	1990	1991	1992	1993
Army	77.9	72.5	67.0	63.3
Navy	99.5	94.9	84.8	84.6
Air Force	92.4	83.6	80.2	83.9
Defense Agencies	18.3	20.6	21.2	21.3
Defense Wide	2.9	4.4	17.7	14.6
Defense Medical Program	–	–	(9.1)	(9.5)
GRAND TOTAL	291.0	276.0	270.9	267.6

[1]Excludes Cost of Desert Shield/Desert Storm.
SOURCE: Secretary of Defense Press Briefing, January 29, 1992.

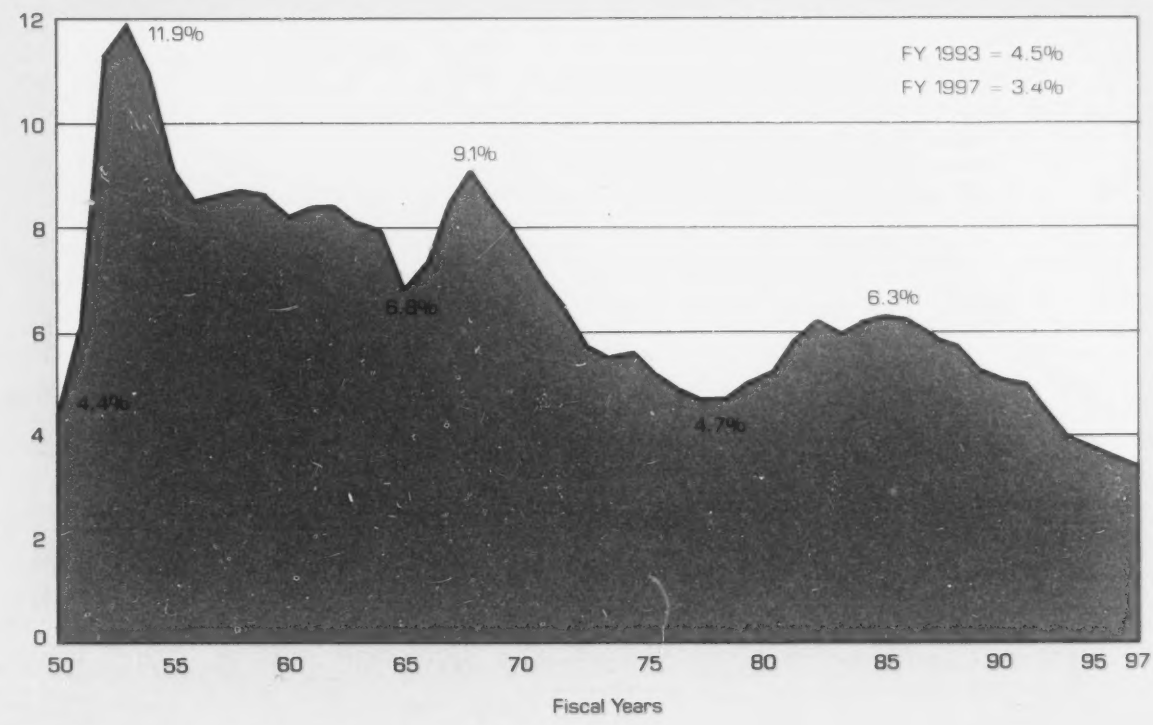
equip larger forces if major threats to U.S. interest emerge in the future.

While the DoD will put fewer new advanced weapons systems into production in the future, the aggressive pursuit of new technologies will be essential to maintaining the advantages U.S. armed forces need to deter and prevail in future conflicts. A weapons program will move to full-scale production only after verifying the need for producing the system, and after minimizing technical, manufacturing, and operational risks. The Pentagon will also emphasize the upgrading of existing weapons systems using proven technologies, when operational needs can be met, instead of producing new weapons systems.

"We still want our armed forces to be the best equipped in the world. But we can now afford to take more time to refine the capabilities of new systems, moving into production only after we are fully satisfied that we'll get what we need at a price the taxpayers can afford," Cheney said.

Defense Outlays as a Share of GNP

FIGURE 5-8



SOURCE: Secretary of Defense Press Briefing, January 29, 1992.

New National Security Strategy

The FY 1993 budget continues to implement the new national security strategy, shifting U.S. defense priorities away from the Cold War policy of containment, and toward a new emphasis on response to regional contingencies. The United States will continue to provide the leadership necessary to promote global peace and security. Its forces will be shaped by the need to provide strategic deterrence and defense, forward presence, crisis response and reconstitution.

Force Structure and Personnel

Today's defense challenges can be met by a much smaller active and reserve force. This base force acknowledges the changing world order, domestic fiscal constraints, and the needs of the new national security strategy. To achieve lower base force levels, reductions are planned in the number of active duty, reserve, and civilian personnel. The manpower needs of the Persian Gulf War delayed the start of the military drawdown, but it has since resumed at an accelerated rate. Active duty end strength will be reduced by 138,000 in FY 1992 and 99,000 in FY 1993, a faster pace than last year's plan to reduce strength by 88,000 in FY 1992 and 91,000 in FY 1993.

From its post-Vietnam peak of 2,174,000 in FY 1987, active military end strength will be down to 1,664,000 by FY 1995, a reduction of 530,000. By FY 1997, the number will drop to 1,626,000—about 25% below the 1987 peak, and reserve personnel levels will be 20% below FY 1987 levels.

DoD civilian strength will fall to 904,000 by FY 1997, about 20% below its FY 1987 post-Vietnam peak. This planned decrease reflects both shrinking U.S. military personnel levels and DoD management improvements.

Major Program Changes

B-2 Stealth Bomber

Even in smaller quantities, the B-2 Stealth Bomber will be an essential part of core capabilities, which will remain necessary in an era when the timing and locations of future threats cannot be predicted. The B-2 will retain its potential as a strategic bomber, but will focus now on the weaponry and development necessary to enhance its conventional role in regional conflicts. The Persian Gulf War confirmed the advantage of combining precision weapons and stealth technologies. Twenty B-2's will allow the Air Force to maintain two squadrons, while also permitting aircraft maintenance. With the transformation of the Soviet threat, America's strategic bomber force is less likely to face the sophisticated air defenses for which the B-2 is designated. The current strategic force of B-1B's and B-52's can be adapted to ensure adequate capabilities for strategic nuclear and conventional missions. Stealth technology remains a key advantage for U.S. forces, and the DoD will initiate vigorous exploration of improved stealth technologies. Total B-2 program adjustments will save $14.5 billion through 1997.

Minuteman III ICBM

To help compensate for the termination of the Midgetman small ICBM, the DoD will fund an improved guidance system for the Minuteman III ICBM, along with other measures to extend its service life. This will yield a net savings of $1.0 billion through 1997.

Seawolf Submarine

With the Soviet Union's collapse, the United States no longer needs to proceed with a new class of attack submarine. Therefore, the Seawolf program will be terminated. The existing SSN-688 submarine is among the most capable in the world and will serve the nation well for many more years. The DoD plans to consider a lower cost submarine design that will enable it to modernize in the future, while also maintaining adequate submarine force levels for the coming years. The DoD will also continue to develop other antisubmarine warfare systems. These changes in the submarine acquisition program will save $17.5 billion through 1997.

Comanche Helicopter

With their focus shifted from a Soviet threat to regional contingencies, U.S. forces can be adequately supported with the existing Apache helicopter fleet, to be upgraded with the Longbow advanced fire control radar system. OH-58D reconnaissance and light attack helicopters, and greater use of unmanned aerial vehicles. The DoD will restructure the Comanche light helicopter development program by deferring production and concentrating instead on building prototypes, developing avionics, upgrading the engine, and incorporating Longbow. This program redirection will save $3.4 billion through 1997.

Air Defense Antitank System

Because non-Soviet air threats to U.S. ground forces are limited in number and capability, U.S. forces can maintain adequate air defense assets with existing air defense fighters and such defense systems as the Patriot, Hawk, and Stinger. The DoD is therefore terminating the Army's air defense antitank system (ADATS). To compensate, the DoD will initiate development of an improved aircraft tracking system and several advanced guidance technologies. The program changes will save $1.7 billion through 1997.

Other Major Program Adjustments

The budget also proposes to: (1) defer funding until after 1997 for the Block III tank, part of the Army's armored systems modernization program, thus saving $400 million; (2) forego engineering and manufacturing development for the Advanced Air-to-Air Missile, to save $600 million; (3) forego procurement, and proceed with RDT&E only for the Navy's Fixed Distribution System underwater surveillance network, saving $700 million; and (4) postpone procurement and stretch out RDT&E for the Army's line of sight antitank program (LOSAT), saving $900 million.

These major program adjustments, the direct result of a reduced threat and a new approach to acquisition of major advanced weapon systems, will produce cumulative net savings of $42.1 billion through FY 1997.

Secretary Cheney has terminated further production of over 100 weapons programs, including the Apache helicopter, M-1 tank, Trident submarine, F-14D remanufacture, F-15,

F-16, Naval Advanced Tactical Fighter, A-12 stealth aircraft, and Peacekeeper missile in 1990 and 1991.

Rescissions Permit Increased Funding for Environmental Cleanup

Savings from the DoD's new program terminations are reflected in a request for rescissions of $7.7 billion in the FY 1992 defense budget. The rescission proposal would also cancel funding for programs that are not required to support the revised Defense program, including some that were budgeted by the DoD and others that were placed in the budget by Congress without the Department's request. Congressional approval of these rescissions is essential if the DoD is to make the most of diminishing defense resources.

The rescission request will not only prevent spending on unnecessary programs, it will also more than offset the budget authority and outlays associated with a planned FY 1992 supplemental request of $1.1 billion to meet DoD environmental restoration and compliance needs. The additional FY 1992 funding is required to allow the DoD to accelerate its cleanup efforts, including those at bases scheduled for closing, to achieve full compliance with federal, state, and local environmental laws and regulations.

Operations Desert Shield and Desert Storm

The announced 1992 budget plan does not include any funding to pay the $61.1 billion incremental U.S. costs for the 1991 operations Desert Shield and Desert Storm. Under the 1990 Budget Enforcement Act, U.S. spending on the Persian Gulf War is treated as an emergency funding requirement, not subject to the budget ceilings set by Congress and the Administration.

To offset these incremental costs, U.S. allies have pledged to contribute $54 billion. The U.S. will not replace some types of damaged or destroyed equipment, valued at $1.2 billion, because the Department has sufficient remaining supplies. That leaves the U.S. a net cost of $5.9 billion for the war.

Of these costs, transfers within the previously appropriated 1990 defense budget covered $1 billion, and a supplemental request in 1990 covered another $2.0 billion, leaving $2.9 billion in costs for the long-term personnel benefits of those who served in the war. In future years, these costs will be paid by the Veterans Administration.

"The war in the Gulf set a remarkable standard of cooperation, and not only on the battlefield. It is absolutely unprecedented that more than four-fifths of the cost of the U.S. part in the operation was paid for by our allies in the Persian Gulf and elsewhere around the world," Cheney noted.

As of January 1992, allied contributions to the U.S. for Gulf war costs were $52.6 billion—$47.0 billion in cash and $5.6 billion in in-kind assistance. Allied payments continue, and the remainder is expected by July 1992.

Other FY 1993 Defense Budget Highlights

Readiness

Although the size of the U.S. military is shrinking, the DoD is committed to ensuring the maintenance of a fully manned, trained, and equipped force. Therefore, the FY 1993 request provides for training, maintenance, and other requirements to sustain the high level of readiness achieved by U.S. forces over the past decade. Active Army ground and air training operations are kept at 800 miles per year for combat vehicles and 14.5 tactical flying hours per month for air crews. Navy steaming days remain at 50.5 days a quarter for deployed fleets and 29 days a quarter for non-deployed fleets. Flying hours for active Air Force tactical air crews will hold at about 21 hours per month.

Research, Development, Testing and Evaluation

Funding for science and technology—research not tied to a specific weapons program—will grow to $12 billion in FY 1993 from $10.6 billion in FY 1992, a real growth rate of

Strategic Missile Defense FY 1993 Amended Budget ($ Millions) TABLE 5-6

Program Element Distribution	FY 1992 Appropriated	FY 1993 Budget
RDT&E		
Limited Defense System	1,434.343	2,134.755
Space Based Interceptors	466.069	575.558
Other Follow-On Systems	666.352	849.596
Research & Support Activities	715.027	754.740
Total RDT&E	3,281.791	4,314.649
MILCON	5.100	50.200
Total	3,286.891	4,364.849

SOURCE: Secretary of Defense News Release, January 29, 1992.

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9.1%, reflecting the Department's emphasis on advanced technology research for application in weapons systems of the future. Total research, development, test and evaluation (RDT&E) will show a 1.5% real growth in FY 1993.

The Strategic Defense Initiative (SDI)

In the Secretary's SDIO (Strategic Defense Initiative Organization) Report to Congress, the Department views protection against limited strikes, whatever their source, as the concept that integrates tactical, theater, and strategic missile defenses. As a result, the Department's Theater Missile Defense and SDI programs have been integrated. This will permit the United States to deploy significant surface-based theater defenses by the mid-1990s. Beginning in 1996 or by the earliest date allowed by the availability of appropriate technology, it will also allow the U.S. to deploy surface- and space-based elements of a strategic defense capable of providing a highly effective limited defense that meets the full range of contingencies posed by the threat of accidental, unauthorized, and limited ballistic missile strikes. Witnin this concept, the pace at which we can proceed is constrained by how soon the appropriate technology can be made ready for fielding, the availability of funding, and international considerations that include arms control negotiations and the threat from ballistic missiles (see Table 5-6).

Theater Missile Defenses

A top U.S. 1992 priority is to aggressively pursue the development of advanced, rapidly relocatable theater missile defenses for deployment in the mid-1990s. The near-term goal is to improve anti-missile capabilities, beginning with improvements to existing systems, such as the Army's Patriot system and the Navy's Aegis system. Early 1992 plans call for a contingency advanced system capability by the mid-1990s, to be developed under the theater high-altitude area defense (THAAD) program, and a fully developed THAAD system by the end of the decade. The Theater Missile Defense (TMD) program will provide a stand-alone capability that will be improved significantly by the subsequent deployment of space-based surveillance systems and space-based interceptors (see Table 5-7).

Limited Defense System

In parallel with Theater Missile Defense, SDIO is developing ground-based defenses to provide a highly effective defense of the *entire* United States, including Alaska and Hawaii, against ballistic missile attacks consisting of several tens to up to two hundred reentry vehicles (RVs). The Limited Defense System will consist of several ground sites and space-based elements. The approximate timeframe for the availability of the Limited Defense System will be the year 2000.

As part of the Limited Defense System, SDIO will, as specified in the Missile Defense Act of 1991, develop an ABM Treaty-compliant defense located for deployment at a single site—Grand Forks, North Dakota—"by the earliest date allowed by the availability of appropriate technology or by Fiscal Year 1996." Although this initial site will not protect the entire United States against the full range of threats of concern, it will provide the foundation for more comprehensive ballistic missile protection. Additionally, it will furnish valuable strategic defense command, control and operating experience to U.S. forces, and will facilitate development and deployment of additional ground-based sites and space-based sensors of the Limited Defense System called for in the Missile Defense Act of 1991.

Space-Based Interceptors

Space-based interceptors offer the most cost- and militarily-effective means of providing highly effective protection, on a global basis, against limited ballistic missile attacks. SDIO will conduct such research and development to provide options to integrate a possible future deployment of Brilliant Pebbles with other strategic and theater missile defense systems. This will not only enhance protection of the United States against an attack by up to 200 RV's, but it will also provide a global capability for countering longer range theater ballistic missile

Theater Missile Defense FY 1993 Amended Budget ($ Millions) TABLE 5-7

Program Element Distribution

	FY 1991 Appropriated	FY 1992 Appropriated	FY 1993 Budget
RDT&E			
TMDI Dem/Val[1]	218.200	0.000	0.000
TMD Dem/Val	184.000	802.710	857.725
TMD EMD	0.000	31.000	140.000
Total RDT&E	402.200	833.710	997.725
Procurement			
TMD	0.000	25.000	62.500
Total	402.200	858.710	1,060.225

[1]For FY 1992 And FY 1993 Congress Directed That Tactical Missile Defense Initiative (TMDI) Programs Be Consolidated Within The TMD Program Element.
SOURCE: Secretary of Defense News Release, January 29, 1992.

threats faced by U.S. forces deployed abroad, as well as our friends and allies. The space-based interceptor program is an option which could be available for deployment by approximately the year 2000.

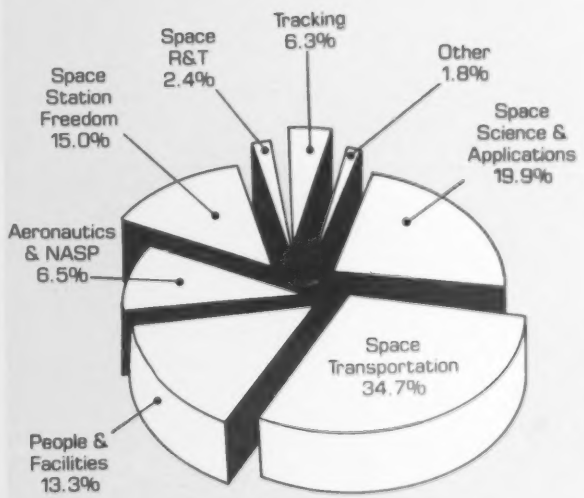
THE NASA BUDGET

The National Aeronautics and Space Administration (NASA) has submitted its FY 1993 Budget request of $14.993 billion (Figure 5-C). The budget demonstrates the Administration's continued support of NASA and the commitment to keep the United States at the forefront of space exploration and aeronautics research. The proposed budget is responsive to the fiscal realities of restrained growth, while allowing NASA the resources it needs to maintain a progressive, efficient civil space program.

The FY 1993 request represents a 4.5% increase over the current year appropriation, or a rate of growth just above the rate of inflation and within last year's guidelines from the appropriations committees. The FY 1993 budget required NASA to balance competing interests and establish priorities because of the constraints placed on its rate of growth for 1992. NASA's contributions span a broad range of concerns, such as life sciences and biomedical research, the environment, aeronautical research and safety, and many more.

The budget is intended to sustain this progress and discovery by focusing on the successful execution of ongoing programs. These include: continuing an effective space science and applications program to expand knowledge of the solar system and the universe; understanding the nature of global environmental change on the planet earth; providing safe and assured access to space—using both the space shuttle and expendable launch services; moving forward with development and preparation for flight of Space Station Freedom; providing the technology, expertise and facilities necessary for continued American leadership in civil and military aviation; providing opportunities for commercialization of space and international cooperation; and supporting a vigorous space technology program essential to the future of the U.S. space program.

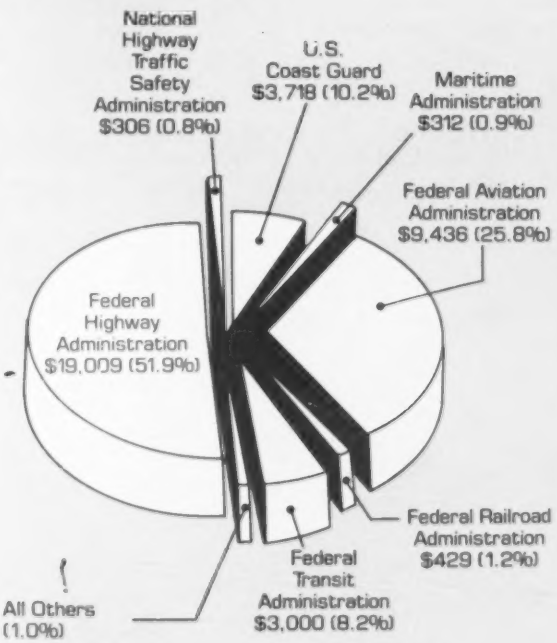
FY 1993 NASA Budget Request FIGURE 5-C



FY 1993 = $14,993 Million

SOURCE: National Aeronautics and Space Administration.

Department of Transportation: FY 1993 Appropriations and Obligation Limitations in Appropriation Acts ($ Millions) FIGURE 5-D



Saint Lawrence Seaway Development Corporation
$12 (0.03%)

Office of Inspector General
$42 (0.1%)

Research and Special Programs Administration
$43 (0.1%)

Office of the Secretary and ICC Transfer
$284 (0.8%)

DOT Total—$36,591 Million

SOURCE: Department of Transportation.

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THE DEPARTMENT OF TRANSPORTATION BUDGET

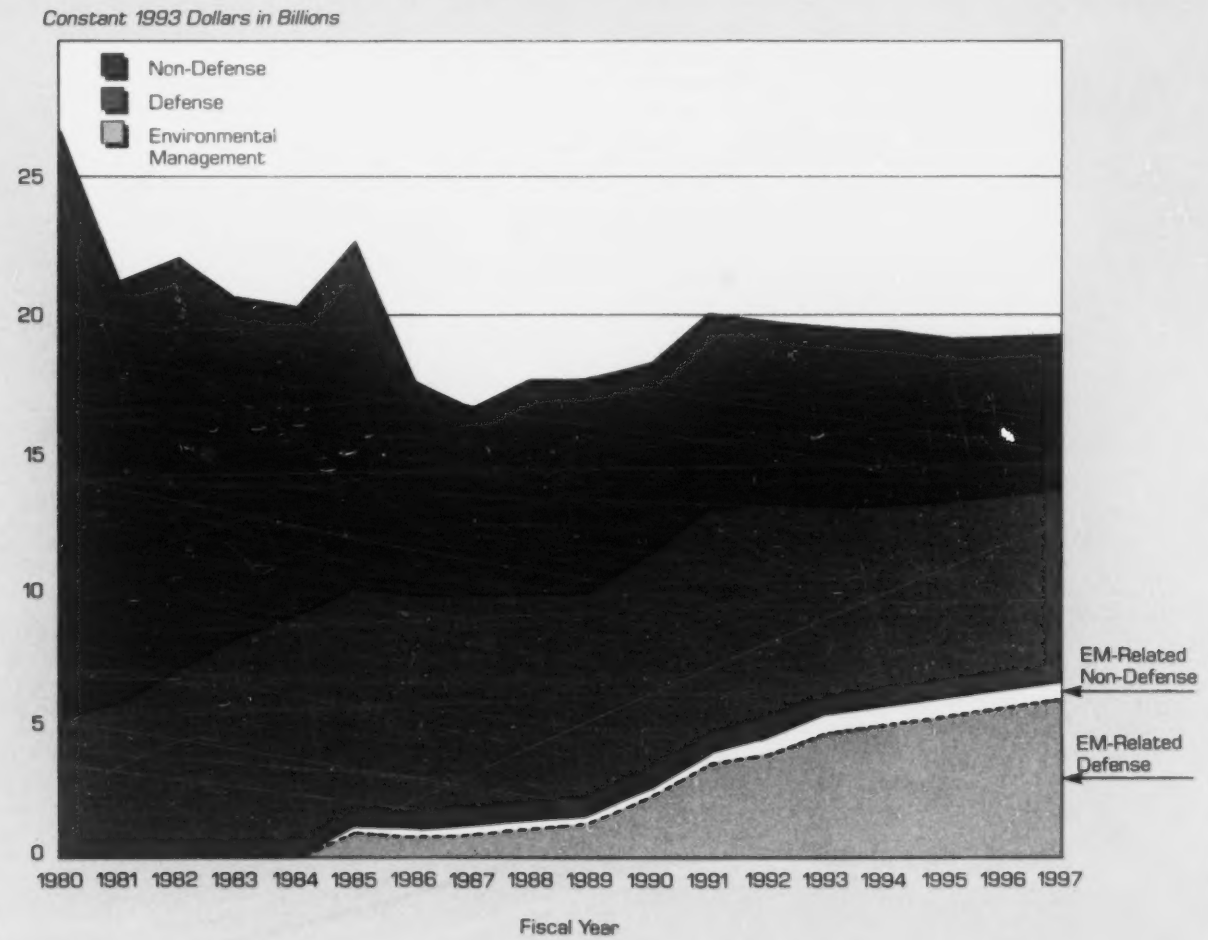
The Department of Transportation's (DOT) FY 1993 budget request totals $36.6 billion in appropriations and obligation limitations (Figure 5-D). This request is 6.3% above the FY 1992 enacted level and provides 41% growth from FY 1989. The DOT budget proposes resources to continue current policies and to address priority program increases. These priority areas include: implementing new statutory responsibilities to authorize aviation programs, especially in surface transportation; addressing critical operating and capital requirements of the Coast Guard; continuing support for safety programs; and investing in R&D. The National Transportation Policy (NTP) also continues to set the major themes for resource allocation within the DOT.

Nearly $27 billion, or 72% of the DOT budget, is for programs directly supporting capital investments in highway, transit, rail and aviation infrastructure. Funds are also requested for maritime infrastructure to facilitate navigation. This investment improves current physical conditions and expands the capacity of the nation's infrastructure.

The budget includes $1.9 billion for programs that are directly safety-related. This is 8.4% over the FY 1992 enacted level, and includes funds for inspections, search and rescue, safety grants, and transportation security. In addition, $18 million in permanent authority is available for hazardous materials-related emergency preparedness planning and training grants to states. The budget strengthens efforts to ensure that transportation services are drug-free and includes $731 million, an increase of 2.8%, to support the Nation's drug reduction strategy. In the area of national security, the budget requests $476 million to support the Coast Guard's military readiness activities and to continue current levels of support for the Ready Reserve Force and the National Defense Reserve Fleet in the Maritime Administration.

There is also $498 million for R&D, a 12% increase over the FY 1992 level. DOT's R&D program supports the operating

Department of Energy FY 1993 Budget Trends FIGURE 5-E



SOURCE: U.S. Department of Energy.

and regulatory responsibilities and also serves as a catalyst to promote productivity improvements and new technology for transportation systems and services. The FY 1993 budget will continue surface transportation initiatives to facilitate travel, particularly in the areas of high speed transportation and intelligent vehicles highway systems.

THE DEPARTMENT OF ENERGY BUDGET

The Department of Energy's (DOE) proposed $19.4 billion budget for Fiscal Year 1993 (Figure 5-E) contains $5.5 billion for environmental cleanup at DOE facilities—an increase of $1.1 billion. Funding for defense activities is down substantially. For high-payoff R&D related to the National Energy Strategy (NES), the government's budget proposes over $900 million, up 18%, of which DOE's portion is $725 million, up 16%. The overall budget increases from $19.0 to $19.4 billion. Spending in defense activities decreases from $8.3 to $7.5 billion, down 9%.

The FY 1993 Conservation R&D budget request is $329.7 million, which is 26% greater than the FY 1992 appropriations, and double the funding for FY 1989. Last year, DOE and the Big Three auto manufacturers announced a jointly-funded $260 million research project to develop new batteries designed to make electric vehicles widely available by the year 2000. The FY 1993 budget proposed a new collaboration with industry for development of hybrid vehicle propulsion technology, where batteries would be combined with other systems such as fuel cells for gas turbines.

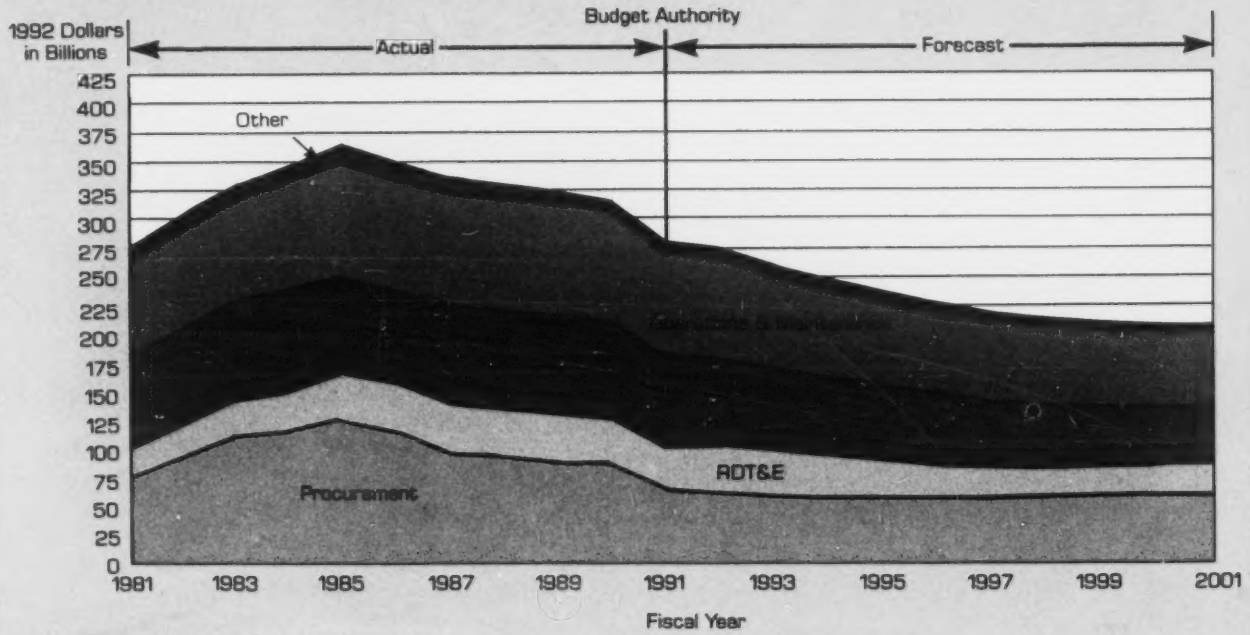
The FY 1993 proposal for solar and renewable energy research is $209.8 million, 26% higher than the FY 1992 request. The budget for nuclear energy R&D is $344.7 million, down slightly from $365.8 million in FY 1992, reflecting progress in light water reactor cost-shared programs as well as a reduction in the space nuclear power spending level. The DOE funds a substantial amount of the nation's basic scientific research, playing a significant role in maintaining and improving U.S. technological expertise and consequent economic competitiveness. The budget for science and technology goes up from $2.7 to $3.0 billion with expansion in selected areas focusing on "small science."

THE MILITARY AND NASA ELECTRONICS MARKET: A TEN YEAR FORECAST

For the 27th consecutive year, the Electronic Industries Association (EIA) Government Division/Requirements Committee has prepared the Ten Year Forecast of Electronic Markets, and for the second consecutive year has looked at NASA business opportunities. There are four principal reasons why the Forecast team sponsored this DoD Forecast and the NASA

Investment Account Decline Bottoms Out in FY1997 as Modernization Program Begins to Drive Procurements

FIGURE 5-F



SOURCE: Electronic Industries Association.

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Forecast. The first, is to provide a vehicle to frame the issues that will be impacting the prospects for top line defense spending and the composition of that spending. The second is to judge the impact associated with the resolution of those issues, and to consider these impacts within a consistent framework so that reasonable judgements about the future can be made. The third is to identify challenges and opportunities for industry that are inherent within the framework of the budget. Finally, EIA prepares this forecast to provide an unbiased basis for corporate planning and decision making. The benefit of such a perspective is valuable at any time, but it is of paramount importance during periods of transition, such as the one in which the United States is engaged in early 1992.

Figure 5-F depicts summary judgements made about the allocation of budget authority at the (051) level between Military Personnel, Operations and Maintenance, RDT&E, Procurement and *Other*.

On the operations side, personnel levels have declined from the levels contained within our 1991 forecast, as a result of budgetary pressures. Personnel end-strength is expected to decline in aggregate to a level, active and reserve, slightly greater than 2.1 million personnel. Operations and Maintenance was also reduced 2-3% from 1991 forecast levels, as a result of budgetary pressures.

Minor adjustments in the "Other" category aside, the remainder of the forecast has been applied to the investment accounts, an action supported by interviews with industry experts and the funding requirements of the Defense Department's modernization program. The twin investment accounts appear on the bottom of Figure 5-F and in total, these accounts bottom out in FY 1997, and then begin to grow modestly.

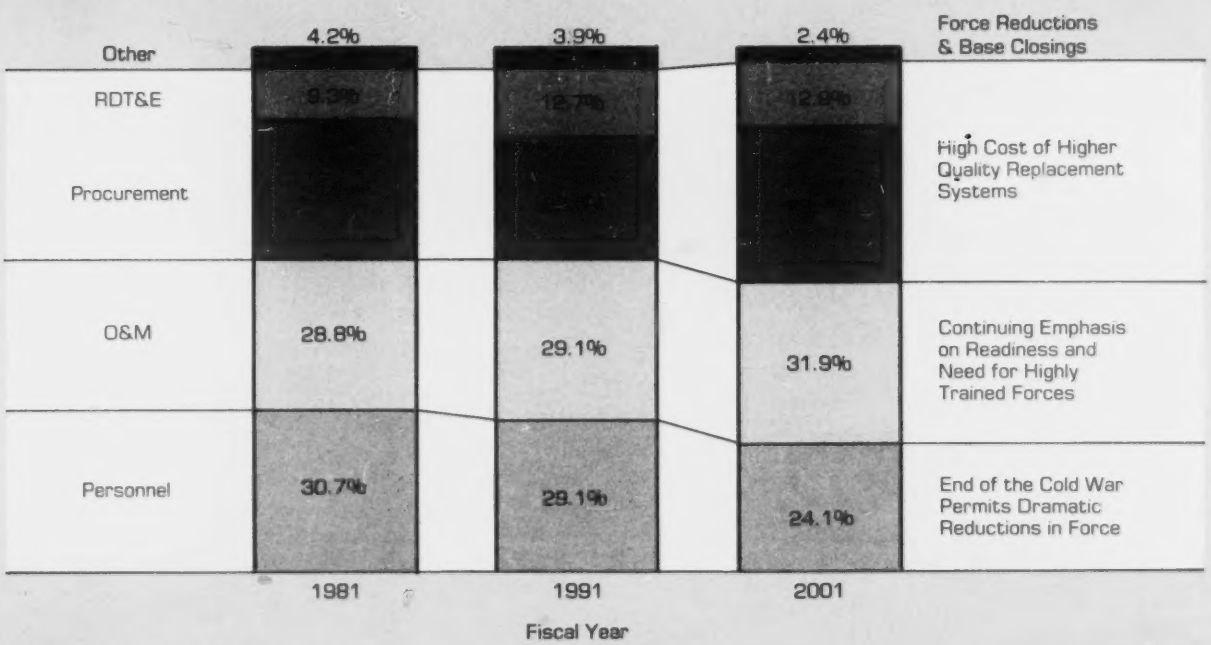
Another way to look at the budget authority picture is depicted in Figure 5-G, which compares the composition of the FY 1981 and FY 1991 budgets with the projected composition of the FY 2001 budget. The high cost of higher quality replacement systems is driving the need for the Defense Department to allocate a greater percentage of its available purchasing power to investment. Operations and Maintenance (O&M) spending is expected to increase slightly in percentage terms as the Defense Department's emphasis on readiness continues. Finally, force levels, and the personnel associated with them, decline as a result of this shift in overall emphasis.

There were several principal messages received during our interviews of over 400 experts:

- The Gulf War has not changed the fundamental outlook for defense spending. However, the aftermath of the Soviet Coup attempt did.
- The draw down in force structure articulated by Secretary Cheney will not be sufficient to accommodate readiness and force modernization goals. Consequently, the Forecast Subcommittee has forecast force structure levels below "Base Force" levels to achieve a balanced operations and investment mix within available funding.
- We expect a continuation of the Administration's policy of "Industrial Darwinism" regarding the defense indus-

Budget Authority Shifts Reflect End of Cold War and Continued Emphasis on Technology and Readiness

FIGURE 5-G



SOURCE: Electronic Industries Association.

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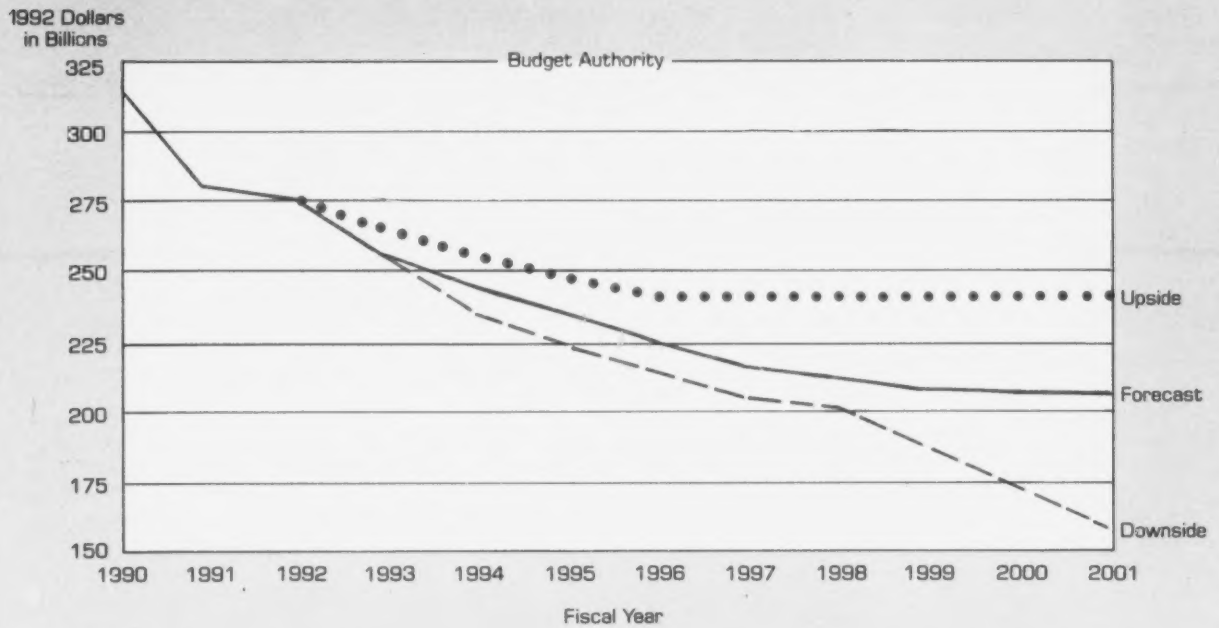
Limited Upside Potential and Significant Downside Risk Surround The Defense Outlook

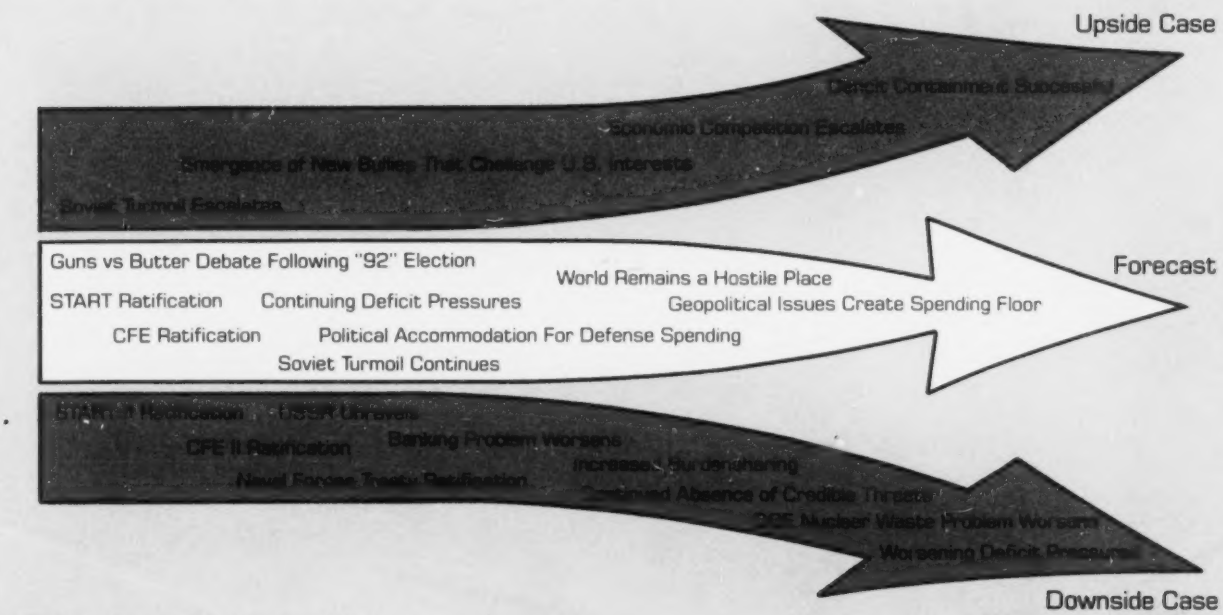
FIGURE 5-H



SOURCE: Electronic Industries Association.

Possible Future Defense Spending Directions

FIGURE 5-I



SOURCE: Electronic Industries Association.

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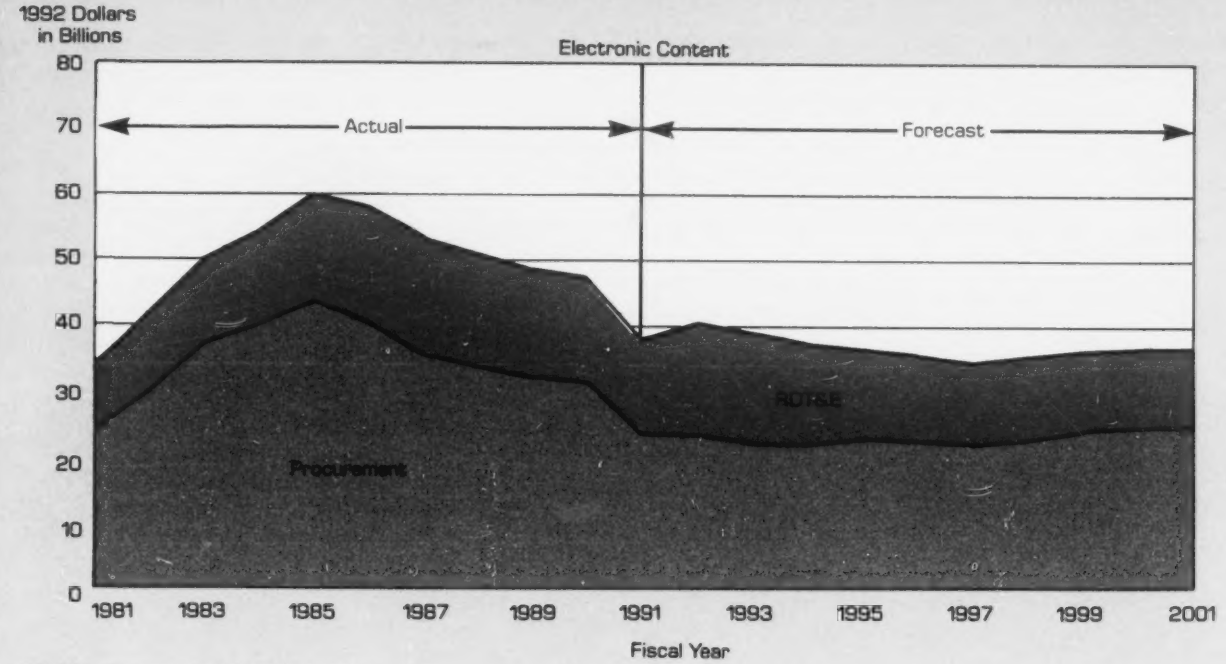
RTD&E Electronics Mirrors Procurement Account Trends

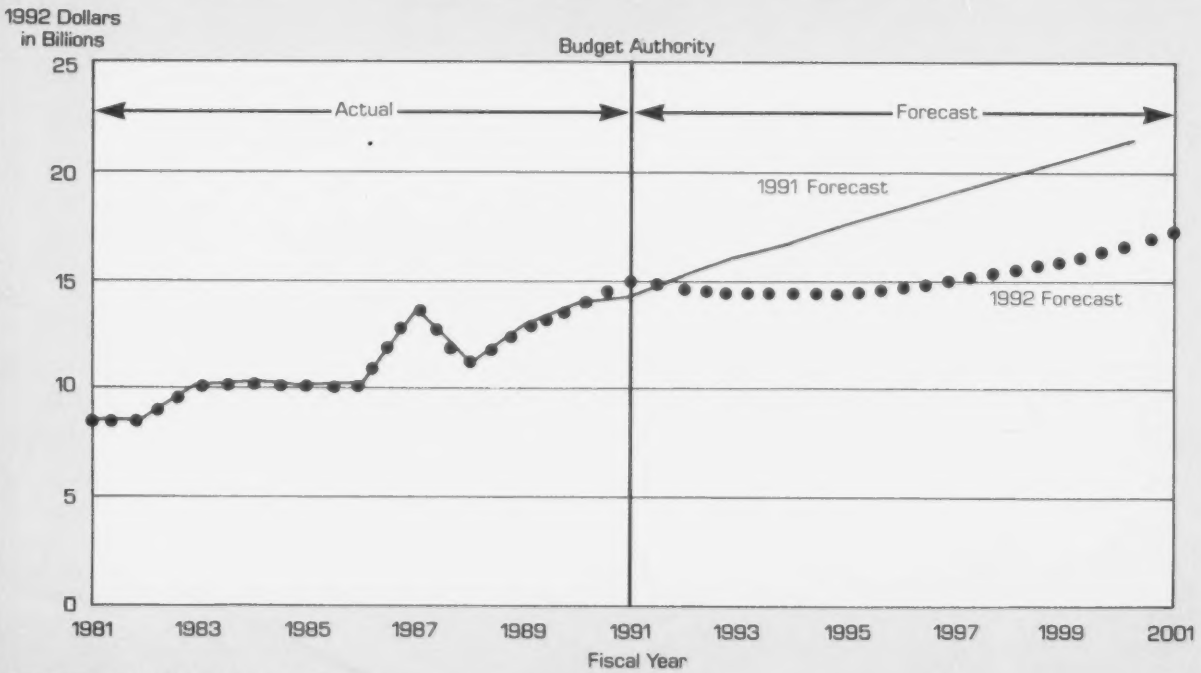
FIGURE 5-J



SOURCE: Electronic Industries Association.

NASA Funding Prospects Dramatically Impacted by Budget Summit Agreement

FIGURE 5-K



SOURCE: Electronic Industries Association.

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trial base. While this policy will produce uncertainty and dislocations within the industry in the short run, in the long run we believe the policy will produce a stronger and more resilient defense industrial base.

- We expect a continuation of support for command, control, communications, and intelligence programs in the wake of the Persian Gulf War, with the expectation of real budget authority growth.
- We have seen a revalidation of air-lift and sea-lift requirements in the wake of Desert Storm (the allied war effort in the Persian Gulf War). This area has enjoyed enduring support within the Congress, and the results of the congressionally mandated mobility study are expected to support the requirement for additional assets.
- We expect that the scope and size of the SDI program will be dramatically altered in the near future. This metamorphosis is expected to emphasize Tactical Missile Defense aspects of the program and de-emphasize space-based concepts.
- Finally, those interviewed expect a healthier relationship to exist between the Defense Department and its suppliers. This shift in the pendulum results from the confluence of many factors, including the realities of the budget picture we have presented here and a general dissatisfaction with the "status quo".

Figure 5-H displays EIA's 1992 forecast, bracketed by an upside and downside case. The upside and downside cases were drawn from the interviews and represent the outer limits of the forecasts discussed. The Forecast Subcommittee believes that there is only a limited upside potential associated with the forecast and a significant downside risk in the later years of the forecast.

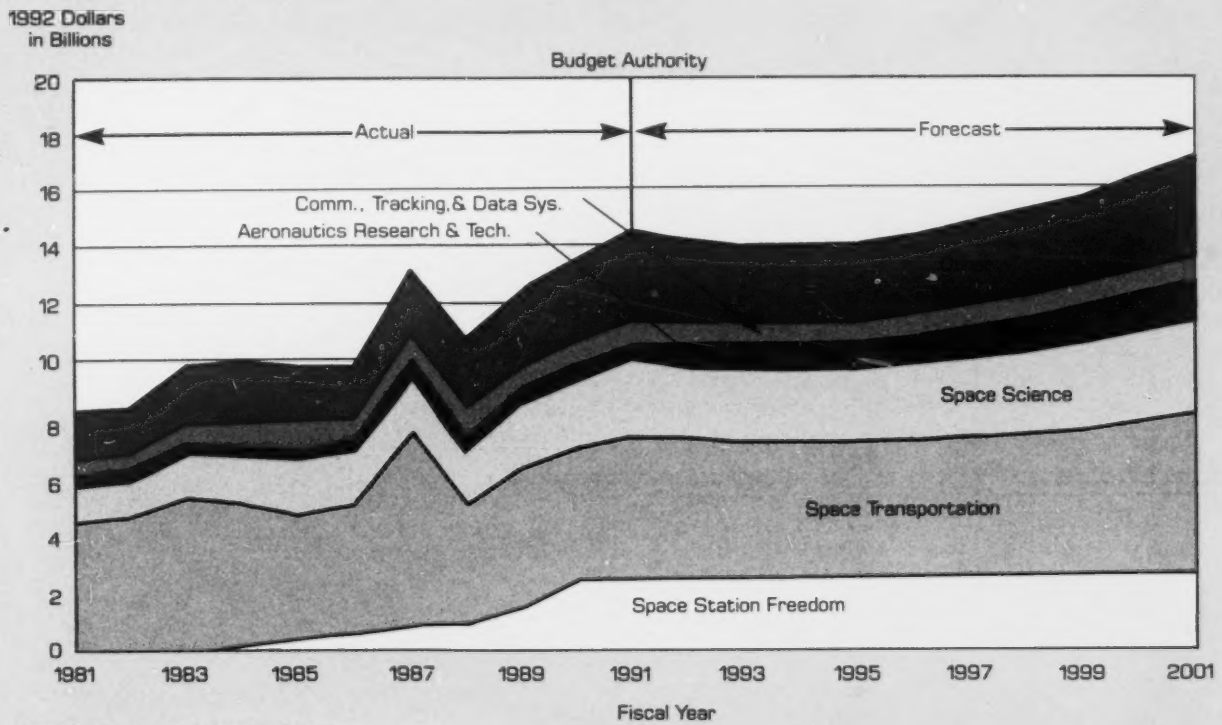
The levels of funding that will ultimately be provided will depend on a variety of factors, as illustrated in Figure 5-I. As time passes, a number of signposts will appear that will signal whether we are on the path charted and articulated within the forecast, or if we are beginning to move toward one of the extremities.

Within the base case, we have assumed: continuing budget reduction pressures, a major "Guns versus Butter" debate following the 1992 elections; ratification of START and CFE; a continuation of turmoil within the Soviet Union and its ex-satellite states; the development of a political accommodation that recognizes our responsibilities within the world community near the end of the 1990s; and the creation of a floor for the defense budget.

Factors that would cause the budget to move toward the upside include: an escalation of turmoil within the Soviet Union; the emergence of new bullies that challenge vital United States interests; an escalation in the economic competition between the European community, the United States, and Japan; and, finally, the successful containment of the deficit to the point that it is no longer a political issue.

Conversely, factors that would cause us to move toward the other extreme include a continuation of the pattern established with the INF, START, and CFE treaties. These trea-

NASA Real Growth Resumes in Fiscal 1996 FIGURE 5-L



SOURCE: Electronic Industries Association.

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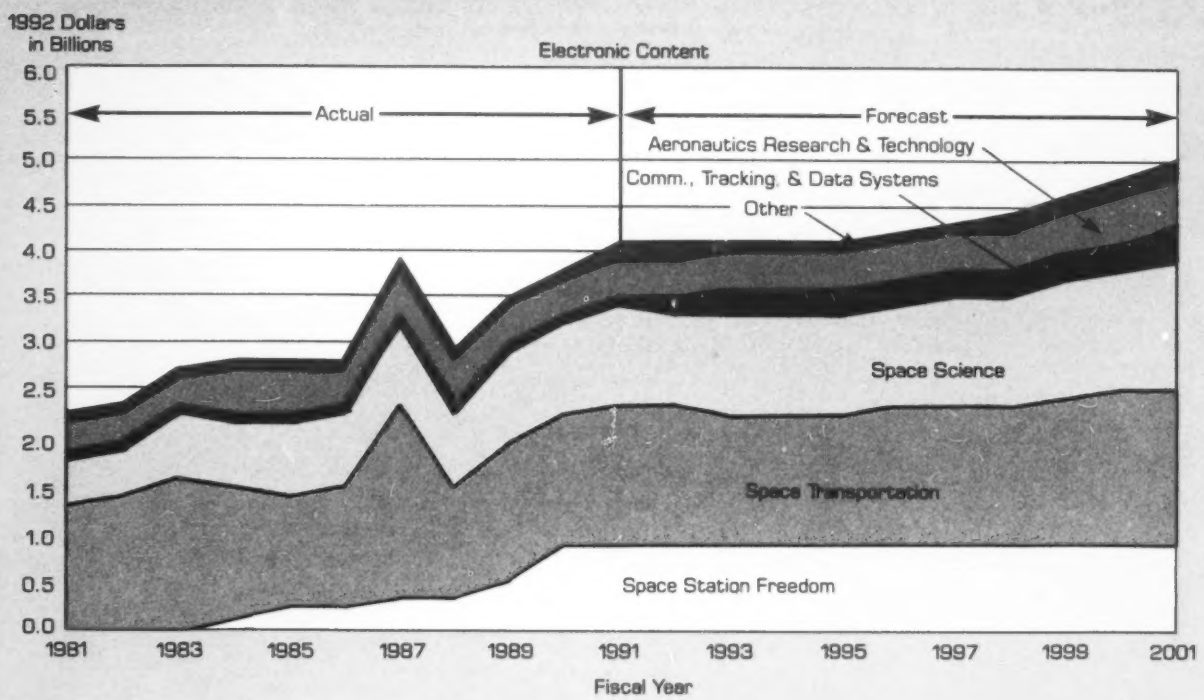
Electronic Content Growth Follows NASA Budget Authority Closely

FIGURE 5-M



SOURCE: Electronic Industries Association.

ties could lead to the ratification of a series of follow-on treaties: START II, CFE II, and even perhaps a naval treaty that could trade off, for example, United States aircraft carriers for Soviet submarines.

As indicated in Figure 5-J, the budget authority forecast presented translates to an outlook for defense electronics that mirrors investment account trends. Investment account related electronics are estimated to be $38.3 billion within the FY 1991 budget and $37.0 billion within the FY 2001 budget. This represents a 3% aggregate decline throughout the forecast period.

As we move into the decade of the 1990s, a challenging period is expected for our industry as a whole. If the prognosis contained within the forecast is correct, the defense electronics industry decline these past six years is largely behind us, and a period of relatively stable funding, in the aggregate, lays on the path ahead.

We should be mindful that the lessons learned from the Persian Gulf War generally favor the defense electronics industry. The effectiveness of smart munitions and unmanned strike systems that were employed, the successes that were enjoyed, and the problems that surfaced as a result of exercising our space and C3I assets, among other factors, are expected to contribute to a continuation of emphasis on developing and refining electronics.

Targets of opportunity will exist, but selectivity will be of paramount importance, given the competition for budgetary resources that is expected between the Services and mission areas, and the stiff competitive environment that will undoubtedly exist within the industry. The challenge on individual firms will be to focus resources and to make reasoned mission area and programmatic investments that further their strategic objectives.

Within the environment we have just described, the Forecast Subcommittee's projection of NASA's future budget authority prospects is very different than it was last year, when the Forecast Subcommittee forecasted annual increases of 5% through the end of the decade. The principal element contributing to this dramatic change was the implementation of the Budget Resolution agreement. The decline in congressional support that has resulted from the competition between NASA and other domestic discretionary budget functions, amplified by the other factors previously noted, have produced this forecast change (see Figure 5-K).

As a consequence of these factors, the Forecast Subcommittee anticipates a period of decline in NASA's budget through FY 1993, followed by a period of level funding through FY 1995, and finally modest real growth in the 2-4% range after the middle of the decade (see Figure 5-L).

Looking at the elements that make up this forecast, we anticipate zero real growth for the Space Station throughout the forecast period, while space science, aeronautical research and space transportation share in the modest out-year growth.

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Growth in the electronic content of the NASA program closely tracks the growth in NASA budget authority (see Figure 5-M). The Space Science portion of the budget is the main driver for electronics, with approximately 60% of the funding allocated to electronic systems. The fastest growing element of space sciences is in the advanced sensors area, which is driven by the Earth Observing Systems (EOS) program. The second driver is in the Communications and Tracking portion of the budget, with 50% of the funding allocated to electronic systems.

This information was condensed from the Electronic Industries Association (EIA) Government Division/Requirements Committee 27th annual Ten Year Forecast of Defense, NASA and Other Federal Government Agencies' Markets. To order a complete report, contact John Geron, 202/457-4944 or Fax 202/457-4910.

Electronic-Related Products and Services

The applications of electronics have expanded significantly over recent history, and the impact has been felt especially by the automotive and aerospace industries. Electronic-related industries are defined as those which produce products which are partially electronic, or provide services integral to the operation of an electronic product. Products and services discussed in this section include those with electronic features or components which have had a definite impact on the sale of the end product or service. Electronic equipment has been a major factor in the sales growth of three other industries, as broken down in Figure 6-B. From 1987 to 1991, U.S. factory sales of electronic-related products and services grew from an estimated $41.2 billion to $54.7 billion, a compound annual growth rate of more than 7%. U.S. factory sales of electronic-related products and services make up approximately 20% of the total electronic industries sales volume.

Electronics will continue to play an increasing role in the development and sale of products and services from many industries. This chapter has been developed to highlight the broadening applications of electronics in related industries. The range of product areas, as well as their electronic content, will be updated periodically as appropriate. All electronic content estimates made in this chapter are based on a compilation of research from Department of Commerce publications, other trade associations, and the EIA Marketing Services Research Center.

AEROSPACE

As one of the largest U.S. industries, aerospace makes important contributions to the U.S. economy. It is a major employer and exporter. In the manufacture of its technologically complex, high performance products and systems, it draws upon a wide range of other industries, which contributes to increased employment and speeds the development of technologies in these sectors. Aerospace is the largest component of the defense industry. The *EIA Ten-Year Forecast of Defense Needs* predicts Department of Defense procurements of electronic parts and products will reach $24.7 billion in 1992.

EIA estimates that approximately $28.9 billion of the 1991 dollar value of the aerospace industry represents electronics which are not classified elsewhere in the electronics industries.

According to the *U.S. Industrial Outlook '92*, the aggregate value of aerospace equipment factory shipments is forecast to grow 0.5% in 1992, while imports and exports are forecast to grow 13.9% and 5.4% respectively.

U.S. aerospace trade in 1991 resulted in a surplus of $26.4 billion. According to the *U.S. Industrial Outlook '92*, exports totaled $38.6 billion in 1991 an increase of 2.4%, while imports were $12.3 billion, a gain of 8.4%.

SYSTEMS INTEGRATION AND COMPUTER SERVICES

Software programs are the detailed instructions that guide computers through their tasks. Of the three sectors of the software industry, packaged, custom, and integral software, only integral software is not separable from the electronic hardware.

In addition to firms which specialize in providing integrated computer systems data processing services, hardware and peripherals manufacturers, and software developers have found systems integration to be a lucrative business. Although start-up costs are relatively low for these firms, the total number of firms in the business has been relatively stable over the past few years because the number of mergers, acquisitions, and failed businesses has matched the number of new entrants.

The revenues for systems integration software services were estimated to be more than $23 billion last year. EIA estimates that about one-half of total revenues earned were consulting fees and associated services. The growth of systems integration services, in terms of industry revenues, far exceeds the actual sales growth for integral software manufacturers. This is because, over time, the share of equipment costs has declined as the services component of these systems has increased. Repair and maintenance revenues have been going to both software manufacturers and independent contractors/consultants.

The quality and sophistication of U.S. software programs have given the industry a leading position in the world market, with an estimated 60% share. The greatest threat facing U.S. software companies, particularly those in packaged and

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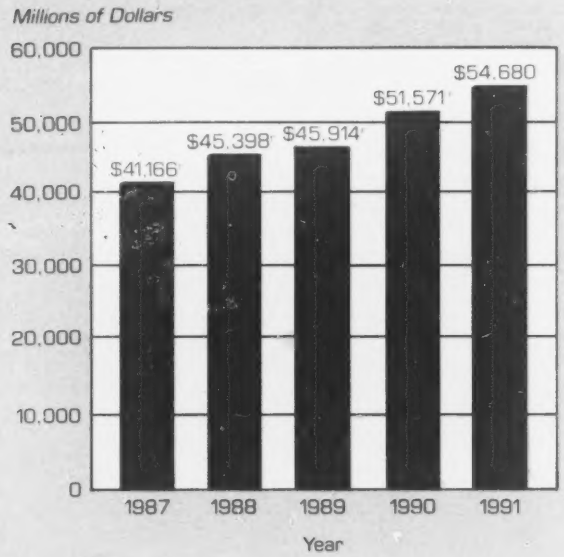
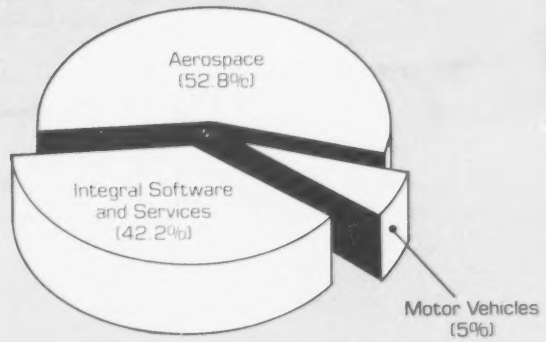
U.S. Factory Sales of Electronic Related Products/Services 1987-1991 ($ Millions) FIGURE 6-A



'Revised
SOURCE: EIA Marketing Services Department.

Electronic-Related Products and Service Groups, U.S. Factory Sales; 1991 FIGURE 6-B



Total Sales = $54.7 Billion

SOURCE: EIA Marketing Services Department.

custom software, is piracy. This problem has effectively kept U.S. software companies out of many foreign markets. As a result, many leading U.S. companies in the computer industry are concentrating on integral systems software and services.

MOTOR VEHICLES

The U.S. motor vehicle industry has had mixed results since its troubled year of the energy crisis in 1979, and the recessionary period in the early eighties. Domestic automobile manufacturers have made dramatic improvements in the quality of their cars, but this measure alone has not stopped the decline in the cumulative market share of the three largest U.S. automakers.

As the automotive market becomes increasingly competitive, U.S. manufacturers are concentrating on incorporating new electronic features to enhance the appeal of their products. New electronic features are appearing predominantly in luxury model cars, but are likely to become standard equipment in mid-range cars during this decade.

EIA estimates that approximately $2.7 billion of the 1991 dollar value of the U.S. motor vehicle industry represents electronics which are not classified elsewhere in electronics industries. These electronic products include gadgets such as clocks and trip computers, passive seat belts, and electronic devices for steering, acceleration and braking. Also included in this sector are devices which control suspension, diagnose and fix startup problems, monitor and recall periodic engine trouble, and control emissions. Car audio equipment is discussed in Chapter 1, Consumer Electronics.

The Freedonia group predicts that high usage rates of automotive electronics will result from continued product innovations and improvements in performance. By the year 1995, Delco Electronics estimates that electronic content in North America will equal $2,000 per vehicle, compared with $395 in 1987. Although a portion of this value is represented in audio equipment, the majority of automotive electronics (currently about two-thirds) is represented by non-entertainment components such as safety and security products. Freedonia states that the 1990s will witness the introduction of such technologies as rear view CRTs, collision warning/mitigation systems and many other advanced electronics. A hybrid system using three integrated microprocessors to regulate engine control, vehicle controls and instrumentation is expected to evolve by the early 1990s. Over 40% average annual sales growth is forecast for electronic restraints, and about 30% average annual sales growth for navigational computers, wiper controls and auto security systems.

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7 Electronics and the World Economy

The electronic industries play a significant role in all facets of the world economy. The strength and resilience of the industry are demonstrated in a number of economic arenas including international trade, employment, and research and development.

INTERNATIONAL TRADE

Total trade in electronics (imports plus exports) topped $148.4 billion in 1991, a 7.1% increase over 1990 trade of $138.6 billion. Exports totaled $71.6 billion in 1991, an increase of 7.0%, while imports of electronic products increased 7.2% to $76.8 billion. The resulting 1991 trade deficit increased 10.3% to $5.2 billion, from $4.7 billion in 1990. Much of the statistical information in this chapter was gathered from the Electronic Industries Association Marketing Services Department publication *ELECTRONICS FOREIGN TRADE*. This monthly statistical journal is designed for rapid and accurate identification of import/export figures for more than 300 electronic products, listed by unit sales and dollar volume.

Communications

U.S. exports of communications equipment rose 4.5% in 1991 to $8.3 billion, while imports rose just 1.6%, totaling $7.9 billion. The communications trade surplus rose 147.8% in 1991 to $389 million. Japan was the largest supplier of communications equipment to the U.S., representing 31.4% of total imports, while Canada was the largest market for U.S.-made communications equipment, accounting for 12.8% of total exports.

Consumer Electronics

Imports of consumer electronics rose 1.3% in 1991 to $14.9 billion. Exports totaled $2.7 billion in 1991, up 13.4%. The consumer electronics trade deficit dropped 1.1% in 1991 to $12.1 billion. The largest supplier of consumer electronics into the U.S. market in 1991 was Japan. Japan by itself accounted for 51.6% of total consumer electronics imports. The largest export market for U.S.-made consumer electronics products was Canada, which consumed 28.4% of exports.

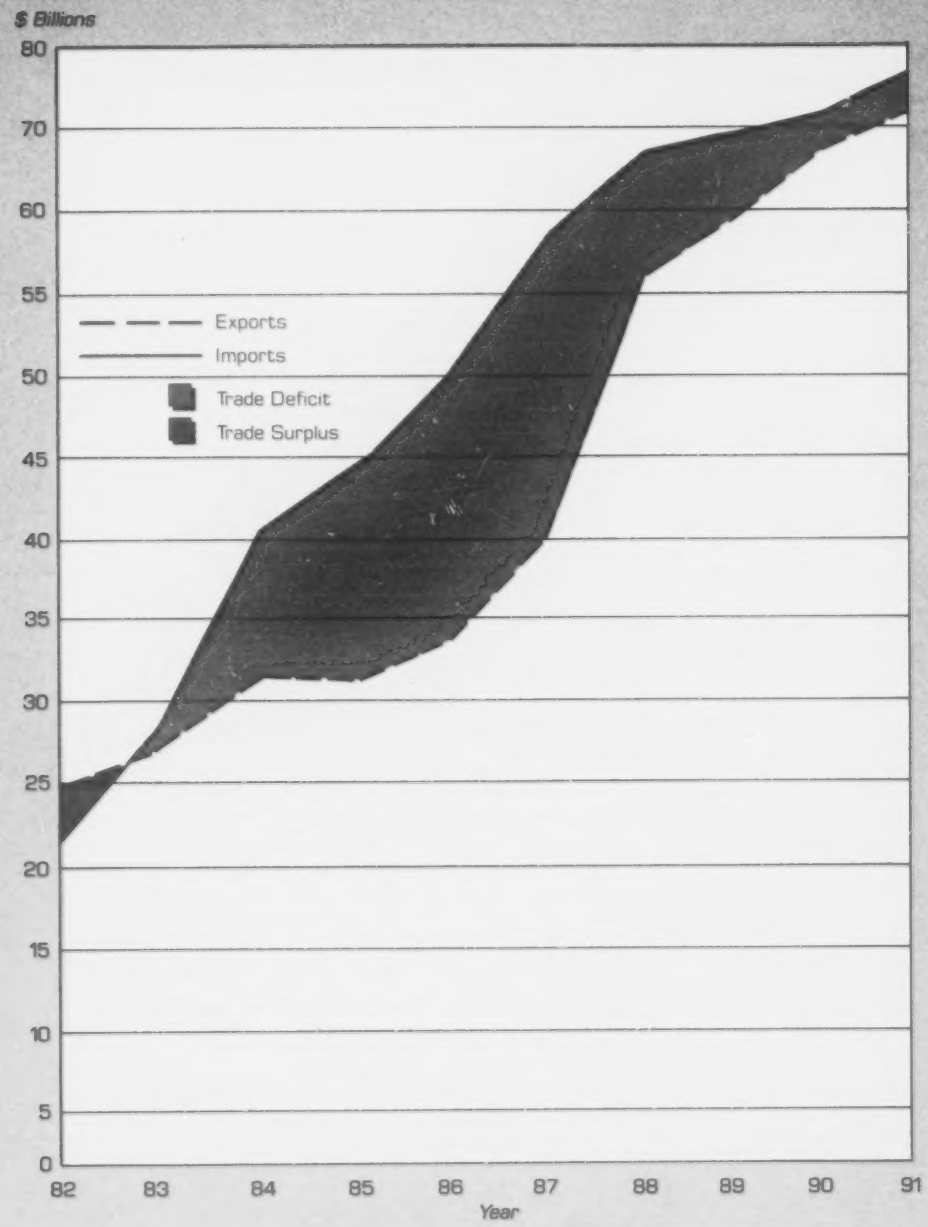
Imports of Electronic Products by Industry ($ Millions); United States, 1987-1991 TABLE 7-1

PRODUCT GROUP	1987r	1988r	1989r	1990r	1991
Communications Products	6,318	7,221	7,743	7,774	7,900
Consumer Electronics	13,307	14,115	15,437	14,699	14,883
Electron Tubes	269	347	552	515	546
Passive Components[1]	7,675	8,962	8,016	9,131	9,380
Computer/Industrial	18,346	22,590	25,373	27,355	30,998
Solid State Products	7,605	10,790	12,304	12,183	13,119
TOTAL[2]	53,519	64,025	69,425	71,657	76,826

[1]Includes Electromechanical Components
[2]Totals may not add due to rounding.
r-The 1987-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and to achieve comparability between the trade data and domestic factory sales data.
SOURCE: U.S. Department of Commerce.

Imports, Exports and Balance of Trade for Electronic Products ($ Billions); United States, 1982-1991

FIGURE 7-A



Electron Tubes

In 1991, U.S. exports of electron tubes totaled $656 million, an increase of 26.6% over exports of $518 million in 1990. Imports, which rose 6% in 1991, totaled $546 million. Trade in electron tubes resulted in a trade surplus of $110 million, up substantially from a trade surplus of $2 million in 1990. The largest supplier of electron tubes into the U.S. was Japan, accounting for 67.5% of total tube imports, while Mexico was the largest consumer of U.S.-made electron tube products.

Solid State Products

Exports of solid state products rose 7.6% in 1991, to $14.5 billion, while imports increased 7.7% to $13.1 billion. The solid state products trade surplus grew 6.5% to $1.4 billion in 1991, from $1.3 billion in 1990. Japan was the leading supplier of solid state products, accounting for 27.9% of total imports. Canada was the largest consumer of U.S.-made solid state products, purchasing $2.7 billion.

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Exports of Electronic Products by Industry ($ Millions); United States, 1987-1991 TABLE 7-2

PRODUCT GROUP	1987r	1988r	1989r	1990r	1991
Communications Products	4,717	6,362	6,474	7,931	8,289
Consumer Electronics	824	1,639	1,914	2,420	2,745
Electron Tubes	317	431	439	518	656
Passive Components[1]	2,987	4,162	5,419	6,936	7,247
Computer/Industrial	23,862	31,926	32,333	35,672	38,201
Solid State Products	6,226	9,747	11,946	13,482	14,504
TOTAL[2]	38,932	54,267	58,525	66,959	71,642

[1]Includes Electromechanical Components
[2]Totals may not add due to rounding.
r-The 1987-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. coverted to the Harmonized Tariff System in 1989) and to achieve comparability between the trade data and domestic factory sales data.
SOURCE: U.S. Department of Commerce.

Balance of Trade for Electronic Products by Industry ($ Millions); United States, 1987-1991 TABLE 7-3

PRODUCT GROUP	1987r	1988r	1989r	1990r	1991
Communications Products	(1,601)	(859)	(1,269)	157	389
Consumer Electronics	(12,483)	(12,477)	(13,523)	(12,279)	(12,138)
Electron Tubes	47	84	(113)	3	110
Passive Components[1]	(4,688)	(4,800)	(2,597)	(2,195)	(2,133)
Computer/Industrial	5,516	9,337	6,960	8,317	7,203
Solid State Products	(1,380)	(1,043)	(358)	1,299	1,385
TOTAL[2]	(14,586)	(9,759)	(10,900)	(4,698)	(5,184)

[1]Includes Electromechanical Components
[2]Totals may not add due to rounding.
r-The 1987-1990 foreign trade data have been revised in order to: insure historical consistency (the U.S. converted to the Harmonized Tariff System in 1989) and to achieve comparability between the trade data and domestic factory sales data.
SOURCE: U.S. Department of Commerce.

Passive Components

Exports of passive components grew 4.5% in 1991 to $7.2 billion, up from $6.9 billion in 1990. At the same time, imports of passive components increased 2.7%, totaling $9.4 billion. The passive components trade deficit fell 2.8% in 1991 to $2.1 billion. The largest supplier of passive components into the U.S. market in 1991 was Japan, accounting for imports of $2.3 billion. Mexico represents the largest market for U.S.-made passive components, consuming 23.4% of all exports.

Computer/Industrial

Exports of computer/industrial equipment rose 7.1% in 1991 to $38.2 billion, but this increase was offset by a 13.3% increase in imports. For all of 1991, imports totaled $31 billion while the computer/industrial trade surplus declined 13.4% to $7.2 billion. The largest supplier of computer/industrial equipment in 1991 was Japan, accounting for 36% of total imports. Canada and Japan represented the largest markets for U.S. computer/industrial goods, consuming 14.4% and 13.2% respectively, of U.S. exports.

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Balance of Trade for Electronic Products by Industry and Country ($ Millions); United States, 1991

TABLE 7-4

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
ALGERIA			
Communication Products	20.3	0.0	20.3
Consumer Electronics	0.2	0.0	0.2
Electron Tubes	0.0	0.0	0.0
Passive Components	6.2	0.0	8.2
Computer/Industrial	5.3	0.0	5.3
Solid State Products	0.7	0.0	0.7
TOTALS	34.7	0.0	34.7
ARGENTINA			
Communication Products	59.0	1.9	57.1
Consumer Electronics	64.6	0.0	64.6
Electron Tubes	1.5	0.0	1.5
Passive Components	50.9	0.6	50.3
Computer/Industrial	302.9	6.4	296.5
Solid State Products	14.6	0.1	14.5
TOTALS	493.5	9.0	484.5
AUSTRALIA			
Communication Products	141.5	17.4	124.1
Consumer Electronics	30.5	1.1	29.4
Electron Tubes	5.3	0.0	5.3
Passive Components	92.3	11.5	80.8
Computer/Industrial	1,152.0	81.2	1,070.8
Solid State Products	66.3	11.4	54.9
TOTALS	1,487.9	122.6	1,365.3
AUSTRIA			
Communication Products	20.6	1.0	19.6
Consumer Electronics	6.1	11.2	(5.1)
Electron Tubes	4.8	0.1	4.7
Passive Components	28.4	10.9	17.5
Computer/Industrial	218.9	40.7	178.2
Solid State Products	22.4	10.0	12.4
TOTALS	301.2	73.9	227.3
BAHAMAS			
Communication Products	5.4	0.0	5.4
Consumer Electronics	1.2	0.0	1.2
Electron Tubes	0.0	0.0	0.0
Passive Components	2.6	0.0	2.6
Computer/Industrial	7.7	0.3	7.4
Solid State Products	0.1	0.0	0.1
TOTALS	17.0	0.3	16.7
BAHRAIN			
Communication Products	2.8	0.0	2.8
Consumer Electronics	0.8	0.0	0.8
Electron Tubes	0.0	0.0	0.0
Passive Components	1.8	0.0	1.8
Computer/Industrial	10.0	0.1	9.9
Solid State Products	0.2	0.0	0.2
TOTALS	15.6	0.1	15.5
BARBADOS			
Communication Products	1.9	0.0	1.9
Consumer Electronics	1.0	0.0	1.0
Electron Tubes	0.3	0.0	0.3
Passive Components	4.0	11.0	(7.0)
Computer/Industrial	7.1	1.4	5.7
Solid State Products	0.2	0.8	(0.6)
TOTALS	14.5	13.2	1.3
BELGIUM			
Communication Products	76.2	5.4	70.8
Consumer Electronics	17.2	16.3	0.9
Electron Tubes	1.0	0.9	0.1
Passive Components	88.9	24.7	64.2
Computer/Industrial	822.4	54.6	567.8
Solid State Products	27.2	2.1	25.1
TOTALS	832.9	104.0	728.9
BELIZE			
Communication Products	1.1	0.0	1.1
Consumer Electronics	3.4	0.0	3.4
Electron Tubes	0.0	0.0	0.0
Passive Components	1.4	0.0	1.4
Computer/Industrial	3.9	0.0	3.9
Solid State Products	0.1	0.0	0.1
TOTALS	9.9	0.0	9.9
BERMUDA			
Communication Products	2.3	0.0	2.3
Consumer Electronics	0.9	0.0	0.9
Electron Tubes	0.0	0.0	0.0
Passive Components	1.6	0.0	1.6
Computer/Industrial	9.5	0.2	9.3
Solid State Products	0.1	0.0	0.1
TOTALS	14.4	0.2	14.2
BOLIVIA			
Communication Products	4.9	0.0	4.9
Consumer Electronics	1.1	0.0	1.1
Electron Tubes	0.0	0.0	0.0
Passive Components	1.2	0.0	1.2
Computer/Industrial	7.7	0.0	7.7
Solid State Products	0.2	0.0	0.2
TOTALS	15.1	0.0	15.1
BRAZIL			
Communication Products	74.9	3.3	71.6
Consumer Electronics	48.3	65.8	(17.5)
Electron Tubes	5.2	0.0	5.2
Passive Components	251.5	61.3	190.2
Computer/Industrial	522.6	66.5	456.1
Solid State Products	110.1	5.1	105.0
TOTALS	1,012.6	202.0	810.6
CANADA			
Communication Products	1,060.1	940.5	119.6
Consumer Electronics	778.2	66.5	711.7
Electron Tubes	75.1	14.8	60.3
Passive Components	1,832.7	1417.5	215.2
Computer/Industrial	5,480.5	2,518.9	2,963.6
Solid State Products	2,701.4	1,420.7	1,280.7
TOTALS	11,728.0	6,378.9	5,351.1
CHILE			
Communication Products	45.4	0.0	45.4
Consumer Electronics	25.8	0.0	25.8
Electron Tubes	0.8	0.0	0.8
Passive Components	19.8	0.1	19.7
Computer/Industrial	133.7	0.3	133.4
Solid State Products	2.0	0.0	2.0
TOTALS	227.5	0.4	227.1
CHINA			
Communication Products	145.2	528.9	(383.7)
Consumer Electronics	4.8	959.9	(955.1)
Electron Tubes	2.8	5.1	(2.3)
Passive Components	36.8	166.4	(129.6)
Computer/Industrial	356.4	216.9	139.5
Solid State Products	8.3	1.8	6.5
TOTALS	554.3	1,878.0	(1,324.7)
COLOMBIA			
Communication Products	23.6	0.0	23.6
Consumer Electronics	9.1	0.5	8.6
Electron Tubes	1.1	0.0	1.1
Passive Components	8.2	0.5	7.7
Computer/Industrial	136.9	0.1	136.8
Solid State Products	4.2	0.0	4.2
TOTALS	183.1	1.1	182.0
COSTA RICA			
Communication Products	15.7	3.2	12.5
Consumer Electronics	3.5	0.1	3.4
Electron Tubes	0.2	0.0	0.2
Passive Components	9.2	19.3	(10.1)
Computer/Industrial	30.7	0.3	30.4
Solid State Products	1.8	0.7	1.1
TOTALS	61.1	23.6	37.5
CYPRUS			
Communication Products	6.7	0.0	6.7
Consumer Electronics	0.5	0.0	0.5
Electron Tubes	0.0	0.0	0.0
Passive Components	1.5	0.0	1.5
Computer/Industrial	5.6	0.0	5.6
Solid State Products	0.3	0.0	0.3
TOTALS	14.6	0.0	14.6
CZECHOSLOVAXIA			
Communication Products	8.7	0.0	8.7
Consumer Electronics	0.5	0.0	0.5
Electron Tubes	0.0	0.0	0.0
Passive Components	1.3	0.1	1.2
Computer/Industrial	25.6	0.1	25.5
Solid State Products	0.6	0.0	0.6
TOTALS	36.7	0.2	36.5
DENMARK			
Communication Products	46.9	19.7	27.2
Consumer Electronics	26.6	15.3	11.3
Electron Tubes	1.0	0.1	0.9
Passive Components	19.9	29.6	(9.7)
Computer/Industrial	160.0	62.8	97.2
Solid State Products	14.5	2.1	12.4
TOTALS	268.9	129.6	139.3
DOMINICAN REPUBLIC			
Communication Products	25.3	4.3	21.0
Consumer Electronics	2.1	0.1	2.0
Electron Tubes	0.1	0.0	0.1
Passive Components	24.1	29.4	(5.3)
Computer/Industrial	14.4	6.2	8.2
Solid State Products	5.0	0.7	4.3
TOTALS	71.0	40.7	30.3
ECUADOR			
Communication Products	8.5	0.1	8.4
Consumer Electronics	10.8	0.0	10.8
Electron Tubes	0.4	0.0	0.4
Passive Components	4.7	0.0	4.7
Computer/Industrial	31.4	0.0	31.4
Solid State Products	0.4	0.0	0.4
TOTALS	56.2	0.1	56.1
EGYPT			
Communication Products	158.6	0.0	158.6
Consumer Electronics	1.1	0.0	1.1
Electron Tubes	1.4	0.0	1.4
Passive Components	28.4	0.0	28.4
Computer/Industrial	155.0	0.1	154.9
Solid State Products	2.4	0.0	2.4
TOTALS	346.9	0.1	346.8
EL SALVADOR			
Communication Products	5.8	0.0	5.8
Consumer Electronics	2.2	0.0	2.2
Electron Tubes	0.1	0.0	0.1
Passive Components	18.6	26.6	(8.0)
Computer/Industrial	10.4	0.2	10.2
Solid State Products	0.1	0.0	0.1
TOTALS	37.2	26.8	10.4

(Continued)

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TABLE 7-4 (continued)

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
FINLAND			
Communication Products	26.1	6.4	19.7
Consumer Electronics	3.1	0.3	2.8
Electron Tubes	1.3	0.1	1.2
Passive Components	7.2	10.1	(2.9)
Computer/Industrial	129.7	59.5	70.2
Solid State Products	14.9	1.4	13.5
TOTALS	182.3	77.8	104.5
FRANCE			
Communication Products	341.1	194.7	146.4
Consumer Electronics	47.9	8.7	39.2
Electron Tubes	26.2	25.7	0.5
Passive Components	242.9	93.2	149.7
Computer/Industrial	1,884.0	494.9	1,389.1
Solid State Products	385.9	117.3	268.6
TOTALS	2,928.0	934.5	1,993.5
FRENCH GUIANA			
Communication Products	121.4	0.0	121.4
Consumer Electronics	0.0	0.0	0.0
Electron Tubes	0.2	0.0	0.2
Passive Components	0.1	0.0	0.1
Computer/Industrial	0.5	0.0	0.5
Solid State Products	0.0	0.0	0.0
TOTALS	122.2	0.0	122.2
GERMANY			
Communication Products	345.0	155.7	189.3
Consumer Electronics	143.3	87.3	56.0
Electron Tubes	30.3	31.2	(0.9)
Passive Components	378.8	435.0	(56.2)
Computer/Industrial	3,933.9	1,551.2	2,382.7
Solid State Products	506.9	304.9	202.0
TOTALS	5,338.2	2,565.3	2,772.9
GREECE			
Communication Products	35.7	0.0	35.7
Consumer Electronics	3.9	0.0	3.9
Electron Tubes	1.7	0.0	1.7
Passive Components	4.5	1.8	2.7
Computer/Industrial	43.4	0.0	43.4
Solid State Products	1.0	0.0	1.0
TOTALS	90.2	1.8	88.4
GUATEMALA			
Communication Products	5.0	0.0	5.0
Consumer Electronics	7.5	0.0	7.5
Electron Tubes	0.1	0.0	0.1
Passive Components	3.5	0.0	3.5
Computer/Industrial	18.8	0.0	18.8
Solid State Products	0.1	0.0	0.1
TOTALS	35.0	0.0	35.0
HAITI			
Communication Products	1.5	0.1	1.4
Consumer Electronics	2.1	0.0	2.1
Electron Tubes	1.2	0.0	1.2
Passive Components	7.8	8.4	(0.6)
Computer/Industrial	2.2	0.3	1.9
Solid State Products	0.2	0.2	0.0
TOTALS	15.0	9.0	6.0
HONDURAS			
Communication Products	14.7	0.0	14.7
Consumer Electronics	1.3	0.0	1.3
Electron Tubes	0.1	0.0	0.1
Passive Components	1.5	0.0	1.5
Computer/Industrial	10.3	0.1	10.2
Solid State Products	0.1	0.0	0.1
TOTALS	28.0	0.1	27.9
HONG KONG			
Communication Products	140.2	231.9	(91.7)
Consumer Electronics	58.6	139.7	(80.1)
Electron Tubes	34.1	0.4	33.7
Passive Components	135.2	301.0	(165.8)
Computer/Industrial	584.7	674.4	(89.7)
Solid State Products	780.1	276.3	483.8
TOTALS	1,713.9	1,623.7	90.2
HUNGARY			
Communication Products	7.2	0.1	7.1
Consumer Electronics	0.9	0.0	0.9
Electron Tubes	0.0	0.1	(0.1)
Passive Components	2.5	0.3	2.2
Computer/Industrial	25.1	0.9	24.2
Solid State Products	0.7	0.0	0.7
TOTALS	36.4	1.4	35.0
ICELAND			
Communication Products	12.7	0.1	12.6
Consumer Electronics	0.9	0.1	0.8
Electron Tubes	0.1	0.0	0.1
Passive Components	2.0	0.0	2.0
Computer/Industrial	7.4	1.4	6.0
Solid State Products	0.6	0.0	0.6
TOTALS	23.7	1.6	22.1
INDIA			
Communication Products	24.0	0.7	23.3
Consumer Electronics	2.4	0.7	1.7
Electron Tubes	1.6	0.1	1.5
Passive Components	17.0	3.9	13.1
Computer/Industrial	145.0	7.5	137.5
Solid State Products	25.9	4.4	21.5
TOTALS	215.9	17.3	198.6
INDONESIA			
Communication Products	78.0	45.7	30.3
Consumer Electronics	2.5	22.2	(19.7)
Electron Tubes	0.4	0.0	0.4
Passive Components	18.2	2.9	15.3
Computer/Industrial	63.0	1.7	61.3
Solid State Products	12.5	26.2	(13.7)
TOTALS	172.6	98.7	73.9
INTERNATIONAL ORGANIZATIONS			
Communication Products	255.1	0.0	255.1
Consumer Electronics	0.0	0.0	0.0
Electron Tubes	0.0	0.0	0.0
Passive Components	0.0	0.0	0.0
Computer/Industrial	0.0	0.0	0.0
Solid State Products	0.0	0.0	0.0
TOTALS	255.1	0.0	255.1
IRAN			
Communication Products	1.1	0.0	1.1
Consumer Electronics	1.0	0.0	1.0
Electron Tubes	0.1	0.0	0.1
Passive Components	2.5	0.0	2.5
Computer/Industrial	21.0	0.3	20.7
Solid State Products	0.2	0.1	0.1
TOTALS	25.9	0.4	25.5
IRELAND			
Communication Products	24.8	51.1	(26.3)
Consumer Electronics	4.2	1.8	2.4
Electron Tubes	0.1	0.0	0.1
Passive Components	75.0	38.4	38.6
Computer/Industrial	619.9	442.4	177.5
Solid State Products	119.1	74.5	44.6
TOTALS	843.1	606.2	236.9
ISRAEL			
Communication Products	161.8	189.4	(27.6)
Consumer Electronics	15.2	1.7	13.5
Electron Tubes	3.2	0.0	3.2
Passive Components	83.5	59.8	23.7
Computer/Industrial	313.9	168.1	145.8
Solid State Products	82.7	145.1	(62.4)
TOTALS	660.3	564.1	96.2
ITALY			
Communication Products	284.9	51.0	233.9
Consumer Electronics	42.1	3.8	38.3
Electron Tubes	9.3	0.7	8.6
Passive Components	133.8	51.8	82.0
Computer/Industrial	970.9	161.8	809.1
Solid State Products	259.7	36.5	223.2
TOTALS	1,700.7	305.6	1,395.1
JAMAICA			
Communication Products	8.6	0.0	8.6
Consumer Electronics	1.7	0.0	1.7
Electron Tubes	0.0	0.0	0.0
Passive Components	4.7	0.9	3.8
Computer/Industrial	17.6	0.0	17.6
Solid State Products	0.4	0.0	0.4
TOTALS	33.0	0.9	32.1
JAPAN			
Communication Products	871.7	2,483.0	(1,611.3)
Consumer Electronics	211.4	7,682.0	(7,470.6)
Electron Tubes	65.1	368.6	(303.5)
Passive Components	519.0	2,258.3	(1,739.3)
Computer/Industrial	5,051.8	11,160.4	(6,108.6)
Solid State Products	1,562.7	3,858.1	(2,095.4)
TOTALS	8,281.7	27,810.4	(19,328.7)
KENYA			
Communication Products	5.7	0.1	5.6
Consumer Electronics	0.1	0.1	0.0
Electron Tubes	0.0	0.0	0.0
Passive Components	0.1	0.1	0.0
Computer/Industrial	5.5	0.0	5.5
Solid State Products	0.1	0.2	(0.1)
TOTALS	11.5	0.5	11.0
KUWAIT			
Communication Products	49.2	0.0	49.2
Consumer Electronics	3.2	0.0	3.2
Electron Tubes	0.0	0.0	0.0
Passive Components	12.5	0.0	12.5
Computer/Industrial	20.7	0.0	20.7
Solid State Products	0.1	0.0	0.1
TOTALS	85.7	0.0	85.7
LUXEMBOURG			
Communication Products	8.7	0.0	8.7
Consumer Electronics	22.9	0.0	22.9
Electron Tubes	0.5	0.0	0.5
Passive Components	0.4	0.2	0.2
Computer/Industrial	29.1	0.1	29.0
Solid State Products	1.1	0.0	1.1
TOTALS	62.7	0.3	62.4
MALAYSIA			
Communication Products	87.3	509.3	(442.0)
Consumer Electronics	3.5	1,108.9	(1,105.4)
Electron Tubes	2.7	0.0	2.7
Passive Components	36.6	200.1	(163.5)
Computer/Industrial	263.7	371.0	(107.3)
Solid State Products	1,628.4	1,629.6	(1.2)
TOTALS	2,002.2	3,818.9	(1,816.7)

(Continued)

TABLE 7-4 (continued)

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
MALTA AND GOZO			
Communication Products	0.6	0.0	0.6
Consumer Electronics	0.1	0.0	0.1
Electron Tubes	0.0	0.0	0.0
Passive Components	0.1	0.5	(0.4)
Computer/Industrial	3.9	0.0	3.9
Solid State Products	1.1	17.6	(16.5)
TOTALS	5.8	18.1	(12.3)
MEXICO			
Communication Products	511.9	353.2	158.7
Consumer Electronics	424.3	1,450.4	(1,026.1)
Electron Tubes	215.9	6.0	209.9
Passive Components	1,694.0	1,979.8	(285.8)
Computer/Industrial	1,586.8	980.5	606.3
Solid State Products	440.9	333.7	107.2
TOTALS	4,875.8	5,103.6	(227.8)
MOROCCO			
Communication Products	11.5	0.1	11.4
Consumer Electronics	0.2	0.1	0.1
Electron Tubes	0.8	0.0	0.8
Passive Components	5.9	0.1	5.8
Computer/Industrial	4.7	0.1	4.6
Solid State Products	1.3	20.1	(18.8)
TOTALS	24.4	20.5	3.9
NETHERLANDS			
Communication Products	271.4	38.2	233.2
Consumer Electronics	74.4	10.0	64.4
Electron Tubes	16.6	6.3	10.3
Passive Components	141.6	26.4	115.2
Computer/Industrial	2,373.6	283.1	2,090.5
Solid State Products	163.2	29.1	134.1
TOTALS	3,040.8	393.1	2,647.7
NETHERLANDS ANTILLES			
Communication Products	5.9	0.0	5.9
Consumer Electronics	7.7	0.1	7.6
Electron Tubes	0.1	0.0	0.1
Passive Components	1.8	0.2	1.6
Computer/Industrial	9.3	0.1	9.2
Solid State Products	0.4	0.0	0.4
TOTALS	25.2	0.4	24.8
NEW ZEALAND			
Communication Products	19.7	0.7	19.0
Consumer Electronics	2.7	0.0	2.7
Electron Tubes	0.3	0.0	0.3
Passive Components	7.5	1.1	6.4
Computer/Industrial	139.7	2.3	137.4
Solid State Products	3.6	0.0	3.6
TOTALS	173.5	4.1	169.4
NICARAGUA			
Communication Products	1.5	0.0	1.5
Consumer Electronics	0.4	0.0	0.4
Electron Tubes	0.0	0.0	0.0
Passive Components	1.6	0.0	1.6
Computer/Industrial	5.8	0.0	5.8
Solid State Products	0.0	0.0	0.0
TOTALS	9.3	0.0	9.3
NIGERIA			
Communication Products	9.1	0.0	9.1
Consumer Electronics	1.3	0.0	1.3
Electron Tubes	0.3	0.0	0.3
Passive Components	5.4	0.0	5.4
Computer/Industrial	21.0	0.1	20.9
Solid State Products	0.2	0.0	0.2
TOTALS	37.3	0.1	37.2
NORWAY			
Communication Products	50.1	20.2	29.9
Consumer Electronics	4.6	0.5	4.1
Electron Tubes	0.8	0.0	0.8
Passive Components	25.2	1.5	23.7
Computer/Industrial	154.7	43.3	111.4
Solid State Products	12.5	2.6	9.9
TOTALS	247.9	88.1	159.8
OMAN			
Communication Products	2.6	0.0	2.6
Consumer Electronics	0.3	0.0	0.3
Electron Tubes	0.1	0.0	0.1
Passive Components	3.5	0.0	3.5
Computer/Industrial	6.1	0.0	6.1
Solid State Products	0.1	0.0	0.1
TOTALS	12.7	0.0	12.7
PAKISTAN			
Communication Products	18.7	0.0	18.7
Consumer Electronics	0.8	0.0	0.8
Electron Tubes	0.1	0.0	0.1
Passive Components	2.1	0.2	1.9
Computer/Industrial	21.5	7.6	13.9
Solid State Products	0.6	0.0	0.6
TOTALS	43.8	7.8	36.0
PANAMA			
Communication Products	10.1	0.0	10.1
Consumer Electronics	34.8	0.0	34.8
Electron Tubes	0.1	0.0	0.1
Passive Components	5.0	0.0	5.0
Computer/Industrial	29.8	0.2	29.6
Solid State Products	0.8	0.0	0.8
TOTALS	80.6	0.2	80.4
PARAGUAY			
Communication Products	24.1	0.0	24.1
Consumer Electronics	50.4	0.0	50.4
Electron Tubes	0.1	0.0	0.1
Passive Components	3.0	0.0	3.0
Computer/Industrial	85.2	0.0	85.2
Solid State Products	2.7	0.0	2.7
TOTALS	165.5	0.0	165.5
PERU			
Communication Products	11.6	0.0	11.6
Consumer Electronics	3.1	0.0	3.1
Electron Tubes	0.4	0.0	0.4
Passive Components	2.1	7.0	(4.9)
Computer/Industrial	37.4	0.0	37.4
Solid State Products	0.6	0.0	0.6
TOTALS	55.2	7.0	48.2
PHILIPPINES			
Communication Products	49.8	165.5	(115.7)
Consumer Electronics	5.1	45.4	(40.3)
Electron Tubes	0.6	0.0	0.6
Passive Components	28.4	27.7	0.7
Computer/Industrial	97.2	63.9	33.3
Solid State Products	580.8	650.2	(69.4)
TOTALS	761.9	952.7	(190.8)
POLAND			
Communication Products	30.8	0.0	30.8
Consumer Electronics	3.5	0.0	3.5
Electron Tubes	1.2	0.0	1.2
Passive Components	4.6	2.9	1.7
Computer/Industrial	46.0	0.8	45.2
Solid State Products	1.5	0.4	1.1
TOTALS	87.6	4.1	83.5
PORTUGAL			
Communication Products	35.7	0.1	35.6
Consumer Electronics	4.9	2.0	2.9
Electron Tubes	2.9	0.0	2.9
Passive Components	10.8	6.1	4.7
Computer/Industrial	72.7	25.3	47.4
Solid State Products	29.6	4.9	24.7
TOTALS	156.6	38.4	118.2
REPUBLIC OF SOUTH AFRICA			
Communication Products	35.3	0.1	35.2
Consumer Electronics	4.2	0.0	4.2
Electron Tubes	1.4	0.0	1.4
Passive Components	11.9	0.1	11.8
Computer/Industrial	213.4	0.7	212.7
Solid State Products	16.0	0.2	15.8
TOTALS	282.2	1.1	281.1
ROMANIA			
Communication Products	7.1	0.0	7.1
Consumer Electronics	0.3	0.0	0.3
Electron Tubes	0.1	0.0	0.1
Passive Components	1.3	0.0	1.3
Computer/Industrial	11.2	0.1	11.1
Solid State Products	0.0	0.0	0.0
TOTALS	20.0	0.1	19.9
SAUDI ARABIA			
Communication Products	128.0	0.0	128.0
Consumer Electronics	7.7	0.0	7.7
Electron Tubes	2.8	0.0	2.8
Passive Components	50.4	0.0	50.4
Computer/Industrial	329.9	0.1	329.8
Solid State Products	2.5	0.0	2.5
TOTALS	521.3	0.1	521.2
SINGAPORE			
Communication Products	136.9	304.2	(167.3)
Consumer Electronics	45.0	855.8	(810.8)
Electron Tubes	19.4	0.2	19.2
Passive Components	208.8	459.4	(250.6)
Computer/Industrial	1,540.9	4,399.3	(2,858.4)
Solid State Products	1,294.1	1,176.8	117.3
TOTALS	3,245.1	6,995.7	(3,750.6)
SOUTH KOREA			
Communication Products	342.5	383.8	(41.3)
Consumer Electronics	52.5	1,476.0	(1,423.5)
Electron Tubes	26.8	7.4	19.4
Passive Components	163.3	198.0	(34.7)
Computer/Industrial	1,021.6	1,300.8	(279.2)
Solid State Products	917.5	1,778.5	(861.0)
TOTALS	2,524.2	5,144.5	(2,620.3)
SPAIN			
Communication Products	143.8	7.8	136.0
Consumer Electronics	33.8	0.7	33.1
Electron Tubes	2.3	0.0	2.3
Passive Components	76.2	14.5	61.7
Computer/Industrial	477.4	34.8	442.6
Solid State Products	37.9	64.0	(26.1)
TOTALS	771.4	121.8	649.6
SWEDEN			
Communication Products	125.0	210.5	(85.5)
Consumer Electronics	11.1	0.6	10.5
Electron Tubes	4.1	0.1	4.0
Passive Components	51.9	61.8	(9.9)
Computer/Industrial	457.0	157.9	299.1
Solid State Products	39.2	17.4	21.8
TOTALS	688.3	448.3	240.0

(Continued)

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TABLE 7-4 (continued)

COUNTRY/INDUSTRY	U.S. EXPORTS	U.S. IMPORTS	BALANCE OF TRADE
SWITZERLAND			
Communication Products	110.1	7.1	103.0
Consumer Electronics	24.0	6.4	17.6
Electron Tubes	2.4	1.2	1.2
Passive Components	49.6	55.7	(6.1)
Computer/Industrial	541.9	123.0	418.9
Solid State Products	49.2	6.0	43.2
TOTALS	777.2	199.4	577.8
TAIWAN			
Communication Products	332.0	513.2	(181.2)
Consumer Electronics	114.3	615.6	(501.3)
Electron Tubes	18.4	49.0	(30.6)
Passive Components	166.9	986.2	(819.3)
Computer/Industrial	736.3	3,535.9	(2,799.6)
Solid State Products	1,156.4	672.9	483.5
TOTALS	2,524.3	6,372.8	(3,848.5)
THAILAND			
Communication Products	88.9	229.9	(141.0)
Consumer Electronics	8.7	381.5	(372.8)
Electron Tubes	8.8	0.0	8.8
Passive Components	45.9	90.8	(44.9)
Computer/Industrial	296.9	544.5	(247.6)
Solid State Products	492.2	382.5	109.7
TOTALS	941.4	1,829.2	(887.8)
TRINIDAD AND TOBAGO			
Communication Products	8.0	0.0	8.0
Consumer Electronics	2.3	0.0	2.3
Electron Tubes	0.1	0.0	0.1
Passive Components	1.5	0.0	1.5
Computer/Industrial	15.0	0.1	14.9
Solid State Products	0.4	0.0	0.4
TOTALS	27.3	0.1	27.2
TURKEY			
Communication Products	73.1	0.0	73.1
Consumer Electronics	4.8	0.2	4.6
Electron Tubes	2.4	0.0	2.4
Passive Components	25.3	0.1	25.2
Computer/Industrial	93.9	0.4	93.5
Solid State Products	6.7	0.0	6.7
TOTALS	206.2	0.7	205.5
UNION OF SOVIET SOCIALIST REPUBLICS			
Communication Products	22.4	0.0	22.4
Consumer Electronics	6.4	0.0	6.4
Electron Tubes	0.0	0.4	(0.4)
Passive Components	3.9	0.3	3.6
Computer/Industrial	99.6	0.1	99.5
Solid State Products	4.6	0.1	4.5
TOTALS	136.9	0.9	136.0
UNITED ARAB EMIRATES			
Communication Products	32.1	0.1	32.0
Consumer Electronics	4.0	0.4	3.6
Electron Tubes	0.3	0.0	0.3
Passive Components	10.7	0.0	10.7
Computer/Industrial	37.5	0.7	36.8
Solid State Products	0.6	0.0	0.6
TOTALS	85.2	1.2	84.0
UNITED KINGDOM			
Communication Products	618.5	218.5	400.0
Consumer Electronics	100.9	41.6	59.3
Electron Tubes	42.1	26.5	15.6
Passive Components	347.5	171.5	176.0
Computer/Industrial	3,623.2	1,335.0	2,288.2
Solid State Products	889.0	229.8	659.2
TOTALS	5,621.2	2,022.9	3,598.3
URUGUAY			
Communication Products	6.4	0.0	6.4
Consumer Electronics	8.9	0.0	8.9
Electron Tubes	0.3	0.0	0.3
Passive Components	1.7	0.0	1.7
Computer/Industrial	23.4	0.0	23.4
Solid State Products	0.1	0.0	0.1
TOTALS	40.8	0.0	40.8
VENEZUELA			
Communication Products	73.5	0.1	73.4
Consumer Electronics	58.5	0.0	58.5
Electron Tubes	1.5	0.0	1.5
Passive Components	28.2	4.3	23.9
Computer/Industrial	276.0	0.6	275.4
Solid State Products	5.0	0.0	5.0
TOTALS	442.7	5.0	437.7
YUGOSLAVIA			
Communication Products	10.0	0.0	10.0
Consumer Electronics	1.1	0.0	1.1
Electron Tubes	1.0	0.4	0.6
Passive Components	3.4	2.4	1.0
Computer/Industrial	35.1	0.2	34.9
Solid State Products	1.4	0.9	0.5
TOTALS	52.0	3.9	48.1

Top 10 U.S. Trade Partners ($ Millions), 1991

TABLE 7-5

U.S. IMPORTS (TOP 10 SUPPLIERS)

PRODUCT GROUP	JAPAN	SINGAPORE	CANADA	TAIWAN	SOUTH KOREA	MEXICO	MALAYSIA	GERMANY	UNITED KINGDOM	CHINA
Communications Products	2,483	304	941	513	384	353	509	156	219	529
Consumer Electronics	7,682	656	66	616	1,476	1,450	1,109	87	42	960
Electron Tubes	369		15	49	7	6		31	26	5
Passive Components[1]	2,258	459	1,417	986	198	1,980	200	435	172	160
Computer/Industrial	11,160	4,399	2,517	3,536	1,301	980	371	1,551	1,335	217
Solid State Products	3,658	1,177	1,421	673	1,779	334	1,630	305	230	2
TOTAL	27,610	6,995	6,377	6,373	5,145	5,103	3,819	2,585	2,024	1,879

U.S. EXPORTS (TOP 10 MARKETS)

PRODUCT GROUP	CANADA	JAPAN	UNITED KINGDOM	GERMANY	MEXICO	NETHERLANDS	SINGAPORE	FRANCE	TAIWAN	SOUTH KOREA
Communications Products	1,060	872	619	345	512	271	137	341	332	342
Consumer Electronics	778	211	101	143	424	74	45	48	114	53
Electron Tubes	75	85	42	30	216	17	19	26	18	27
Passive Components[1]	1,633	519	347	379	1,694	142	209	243	167	183
Computer/Industrial	5,481	5,052	3,623	3,934	1,589	2,374	1,541	1,884	736	1,022
Solid State Products	2,701	1,563	889	507	441	163	1,294	386	1,156	918
TOTAL	11,728	8,282	5,621	5,338	4,876	3,041	3,245	2,928	2,523	2,525

[1]Includes Electromechanical Components.
SOURCE: U.S. Department of Commerce.

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Top 10 U.S. Trade Partners by Industry Sector ($ Thousands); 1991

TABLE 7-6

	$ MILLIONS	PERCENTAGE OF TOTALS
COMMUNICATION PRODUCTS		
Total U.S. Imports	7,900	
Japan	2,483	31.43
Canada	941	11.91
China	529	6.69
Taiwan	513	6.50
Malaysia	509	6.45
South Korea	384	4.86
Mexico	353	4.47
Singapore	304	3.85
Hong Kong	232	2.93
Thailand	230	2.91
TOTAL	6,478	82.00
Total U.S. Exports	8,289	
Canada	1,060	12.79
Japan	872	10.52
United Kingdom	619	7.46
Mexico	512	6.17
Germany	345	4.16
South Korea	342	4.13
France	341	4.11
Taiwan	332	4.01
Italy	285	3.44
Netherlands	271	3.27
TOTAL	4,979	60.06

	$ MILLIONS	PERCENTAGE OF TOTALS
ELECTRON TUBES		
Total U.S. Imports	546	
Japan	369	67.54
Taiwan	49	8.98
Germany	31	5.71
United Kingdom	26	4.85
France	26	4.72
Canada	15	2.72
South Korea	7	1.35
Netherlands	6	1.16
Mexico	6	1.10
China	5	0.94
TOTAL	541	99.08
Total U.S. Exports	656	
Mexico	216	32.93
Canada	75	11.46
Japan	65	9.93
United Kingdom	42	6.42
Hong Kong	34	5.20
Germany	30	4.62
South Korea	27	4.09
France	26	4.00
Singapore	19	2.96
Taiwan	18	2.81
TOTAL	554	84.42

	$ MILLIONS	PERCENTAGE OF TOTALS
COMPUTER/INDUSTRIAL		
Total U.S. Imports	30,998	
Japan	11,160	36.00
Singapore	4,399	14.19
Taiwan	3,536	11.41
Canada	2,517	8.12
Germany	1,551	5.00
United Kingdom	1,335	4.31
South Korea	1,301	4.20
Mexico	980	3.16
Hong Kong	674	2.18
Thailand	545	1.76
TOTAL	27,999	90.33
Total U.S. Exports	38,201	
Canada	5,481	14.35
Japan	5,052	13.22
Germany	3,934	10.30
United Kingdom	3,623	9.48
Netherlands	2,374	6.21
France	1,884	4.93
Mexico	1,589	4.16
Singapore	1,541	4.03
Australia	1,152	3.02
South Korea	1,022	2.67
TOTAL	27,650	72.38

	$ MILLIONS	PERCENTAGE OF TOTALS
CONSUMER ELECTRONICS		
Total U.S. Imports	14,883	
Japan	7,682	51.62
South Korea	1,476	9.92
Mexico	1,450	9.75
Malaysia	1,109	7.45
China	960	6.45
Singapore	656	4.41
Taiwan	616	4.14
Thailand	382	2.56
Hong Kong	140	0.94
Germany	87	0.59
TOTAL	14,557	97.81
Total U.S. Exports	2,745	
Canada	778	28.35
Mexico	424	15.46
Japan	211	7.70
Germany	143	5.22
Taiwan	114	4.16
United Kingdom	101	3.68
Netherlands	74	2.71
Argentina	65	2.35
Hong Kong	60	2.17
Venezuela	58	2.13
TOTAL	2,029	73.94

	$ MILLIONS	PERCENTAGE OF TOTALS
PASSIVE COMPONENTS (Includes Electromechanical Components)		
Total U.S. Imports	9,380	
Japan	2,258	24.08
Mexico	1,980	21.11
Canada	1,417	15.11
Taiwan	986	10.51
Singapore	459	4.90
Germany	435	4.64
Hong Kong	301	3.21
Malaysia	200	2.13
South Korea	198	2.11
United Kingdom	172	1.83
TOTAL	8,407	89.62
Total U.S. Exports	7,247	
Mexico	1,694	23.37
Canada	1,633	22.53
Japan	519	7.16
Germany	379	5.23
United Kingdom	347	4.79
Brazil	252	3.47
France	243	3.35
Singapore	209	2.88
Taiwan	167	2.30
South Korea	163	2.25
TOTAL	5,605	77.34

	$ MILLIONS	PERCENTAGE OF TOTALS
SOLID STATE PRODUCTS		
Total U.S. Imports	13,119	
Japan	3,658	27.88
South Korea	1,779	13.56
Malaysia	1,630	12.42
Canada	1,421	10.83
Singapore	1,177	8.97
Taiwan	673	5.13
Philippines	650	4.96
Thailand	382	2.92
Mexico	334	2.54
Germany	305	2.32
TOTAL	12,008	91.53
Total U.S. Exports	14,504	
Canada	2,701	18.63
Malaysia	1,628	11.23
Japan	1,563	10.77
Singapore	1,294	8.92
Taiwan	1,156	7.97
South Korea	918	6.33
United Kingdom	889	6.13
Hong Kong	760	5.24
Philippines	581	4.00
Germany	507	3.50
TOTAL	11,997	82.72

EMPLOYMENT

In 1991 average annual employment in the U.S. electronic industries decreased 5.0%, while the number of production workers dropped 6.4% (see Tables 7-7 and 7-8). All employment segments in the electronics industries declined in 1991. Historical trends in electronics employment compared to employment in other U.S. industries, are illustrated in Figure 7-C.

Job Market Outlook

Long-term employment forecasts prepared by the Bureau of Labor Statistics (BLS) for various segments of the U.S. elec-

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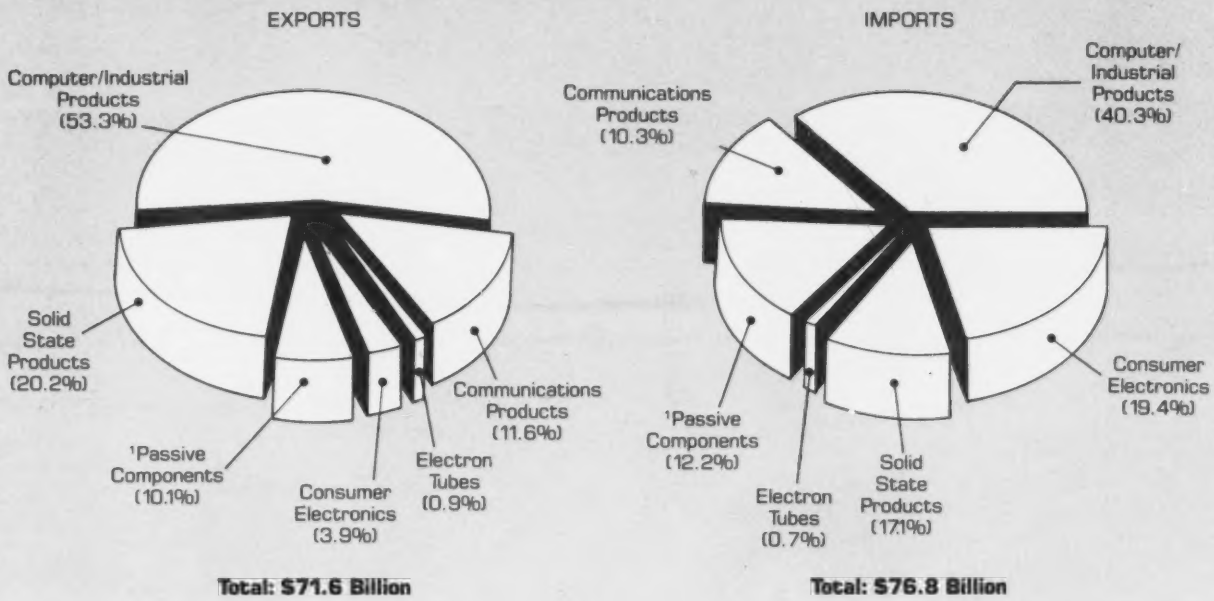
Percentage Share of Imports/Exports by Industry, 1991

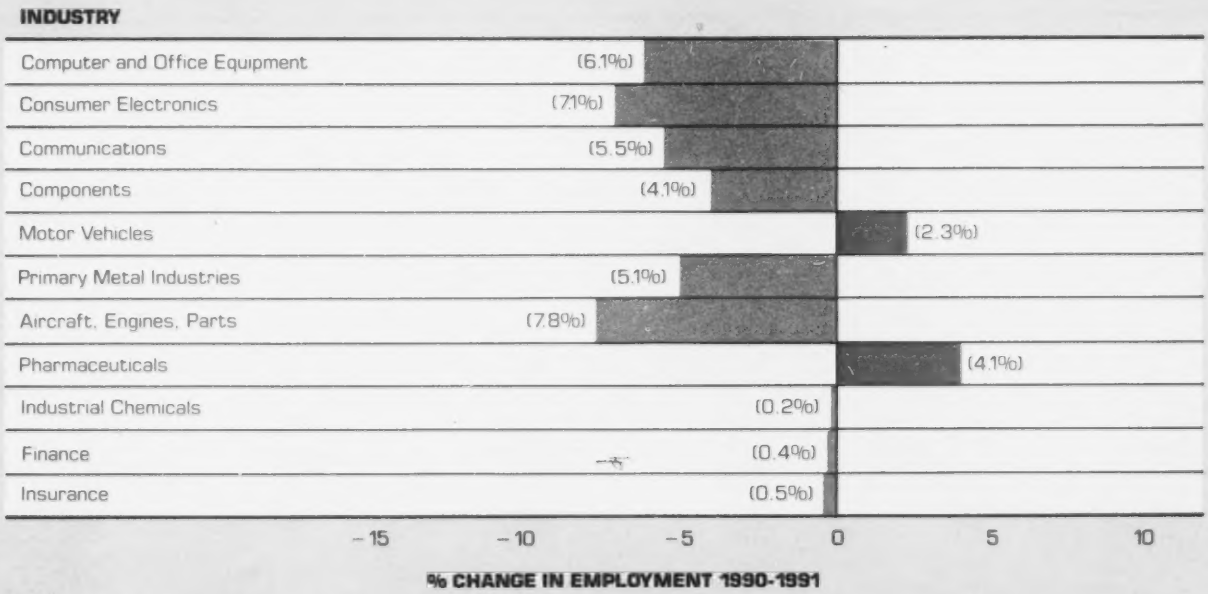
FIGURE 7-B



¹Includes Electromechanical Components.
SOURCE: Tables 7-1 and 7-2

Comparative Employment by Industry, United States, 1990-1991

FIGURE 7-C



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics

Average Annual Employment in the Electronic Industries, (Thousands of Workers); United States, 1988-1991 TABLE 7-7

	1988	1989	1990	1991
Consumer Electronics	62.0	66.1	64.6	60.0
Communications Equipment	591.2	570.3	539.0	509.1
Components	691.2	685.9	645.1	618.6
Computers	459.9	520.0r	502.6r	471.1
Industrial Electronics	243.1	249.0	242.0	233.7
TOTAL	2,047.4	2,091.3r	1,993.3r	1,892.5

r-Revised.
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

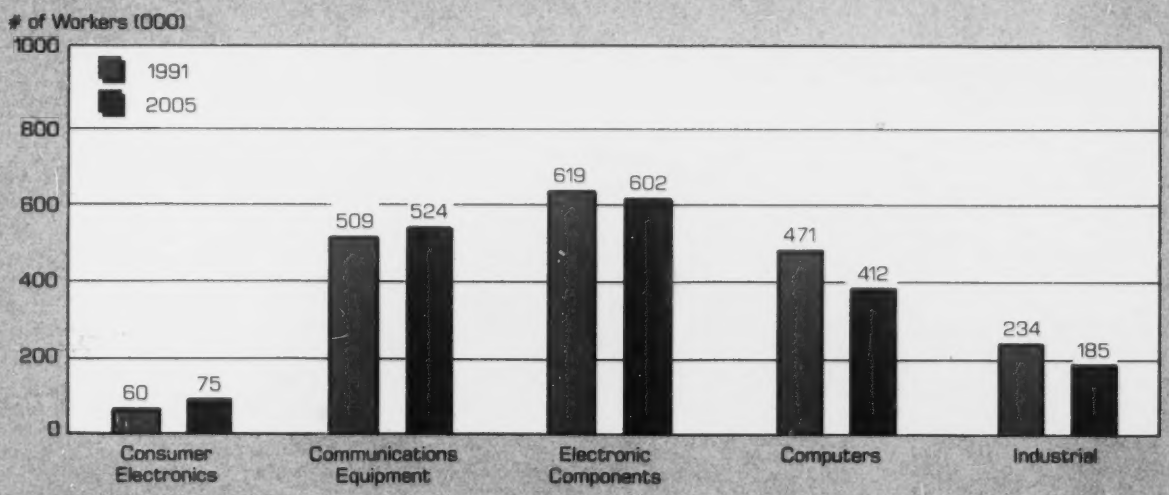
tronics industries in the year 2005 are displayed in Figure 7-D. Employment in the consumer electronics industry is forecast to rise to 75,000 in 2005, up from 60,000 in 1991. Employment in the communications sector is forecast to be 524,000 in 2005, up 2.9% from 1991. An employment decline is expected in the computer & peripherals sector, forecast to drop 12.5% to 412,000 workers. BLS also forecasts employment drops in the components sector as well as the industrial sector, falling 2.7% and 20.9% respectively by the year 2005.

RESEARCH AND DEVELOPMENT (R&D)

National expenditures for research and development (R&D) totaled an estimated $158 billion in 1991, up 5.8% from the $150 billion figure of 1990, according to the National Science Foundation (NSF).

Four principal sectors participate in R&D activities: the federal government, industry, universities and colleges, and other nonprofit institutions. As depicted in Figure 7-G, which shows national R&D expenditures between 1980 and 1991, R&D expenditures have more than doubled in the past decade. The federal government and industry are the two prime sources of funds for R&D. In 1991, these two sectors contributed 46.2% and 49.4%, respectively, toward total R&D expenditures. Industry continues to be the most important performer of R&D. In 1991, industry performed an estimated 71.5% of all R&D activities. Through use of its own funds and those from other sources, such as the federal government, industry spent more than $113 billion in R&D in 1991. The federal government performed approximately 11% of the national R&D effort in 1991, while universities, colleges, and other nonprofit institutions performed 17.4%, according to the NSF.

Employment in the Electronic Industries, (Thousands of Workers); United States, 1991 vs. 2005 FIGURE 7-D



SOURCE: U.S. Bureau of Labor Statistics.

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Average Employment and Earnings in the Electronic Industries, United States, 1988-1991 TABLE 7-8

	1988	1989	1990r	1991p
Consumer Electronics				
All Employees (in thousands)	62.0	66.1	64.6	60.0
Women Employees (in thousands)	28.6	30.5	29.8	27.6
Production-Workers (in thousands)	41.6	45.3	42.8	38.5
Production-Worker Average Weekly Earnings (in dollars)	390.99	386.63	397.23	469.53
Production-Worker Average Hourly Earnings (in dollars)	9.49	9.57	9.76	11.10
Production-Worker Average Weekly Hours	41.2	40.4	40.7	42.3
Production-Worker Average Weekly Overtime Hours	3.4	3.3	3.1	4.9
Communications Equipment				
All Employees (in thousands)	591.2	570.3	539.0	509.1
Women Employees (in thousands)	225.9	217.9	206.1	194.5
Production-Workers (in thousands)	243.7	237.2	224.1	208.1
Production-Worker Average Weekly Earnings (in dollars)	495.49	515.04	535.61	479.41
Production-Worker Average Hourly Earnings (in dollars)	12.08	12.49	12.97	11.58
Production-Worker Average Weekly Hours	41.1	41.6	41.8	41.4
Production-Worker Average Weekly Overtime Hours	2.8	2.7	2.8	3.5
Computers				
All Employees (in thousands)	459.9	520.0r	502.6	471.7
Women Employees (in thousands)	165.3	186.7r	180.4	169.3
Production-Workers (in thousands)	148.3	180.4r	172.7	165.3
Production-Worker Average Weekly Earnings (in dollars)	444.11	465.30	483.42	512.78
Production-Worker Average Hourly Earnings (in dollars)	10.65	11.00	11.51	12.18
Production-Worker Average Weekly Hours	41.7	42.3	42.0	42.1
Production-Worker Average Weekly Overtime Hours	3.0	3.3	3.1	3.4
Industrial				
All Employees (in thousands)	243.1	249.0	242.0	233.7
Women Employees (in thousands)	100.9	103.0	100.1	96.8
Production-Workers (in thousands)	127.9	132.1	126.6	116.6
Production-Worker Average Weekly Earnings (in dollars)	394.06	403.73	423.21	464.74
Production-Worker Average Hourly Earnings (in dollars)	9.52	9.82	10.27	11.28
Production-Worker Average Weekly Hours	41.4	41.1	41.2	41.2
Production-Worker Average Weekly Overtime Hours	3.0	2.8	2.9	3.1
Components				
All Employees (in thousands)	691.2	685.9	645.1	618.6
Women Employees (in thousands)	295.1	292.8	275.4	264.1
Production-Workers (in thousands)	389.4	387.2	377.3	354.8
Production-Worker Average Weekly Earnings (in dollars)	375.14	385.14	403.40	433.54
Production-Worker Average Hourly Earnings (in dollars)	9.24	9.56	10.01	10.60
Production-Worker Average Weekly Hours	40.6	40.3	40.3	40.9
Production-Worker Average Weekly Overtime Hours	3.3	3.3	3.4	3.8

p-Preliminary.
r-Revised.
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

Electronics R&D

Combined federal and company funds for R&D in the electrical and electronic industries (SIC 36) totaled $16.8 billion in 1989, 3.2% more than the 1988 total according to the latest data available from the NSF.

Table 7-9 presents company R&D funds, as well as the R&D/Sales ratios for selected U.S. electronic industries. The office, computing, and accounting machines industry (SIC 357) increased its R&D spending by approximately 50% between 1984 and 1989, compared to 12.4% growth from 1988 to 1989. This industry's R&D/Sales ratio is the highest overall, based on industry classifications used by the NSF. The radio & TV receiving equipment industry (SIC 365) has traditionally spent a small portion of its revenues on R&D, with company R&D funds totaling $85.0 million in 1989, a significant drop from 1988 spending of $139.0 million. The communications industry (SIC 366) increased its company R&D expenditures 14.2% from 1986 to 1989, to $5.8 billion. The electronic components industry (SIC 367) topped $4.3 billion in company R&D expenditures in 1989, while its R&D/Sales ratio increased from 6.6% in 1984 to 8.3% in 1989.

The electronic industries have traditionally outperformed most U.S. industries in the percentage of revenue spent on

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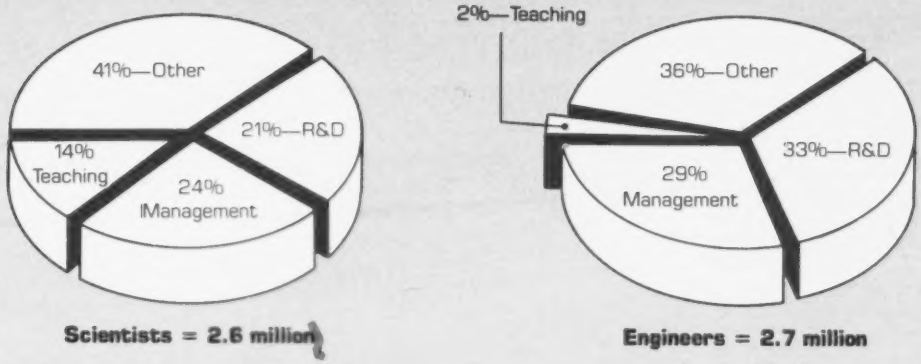
Employed Scientists and Engineers by Primary Work Activity, United States, 1988 FIGURE 7-E



SOURCE: National Science Foundation.

R&D. Increased technological complexity, stiffer foreign competition and short product life cycles are frequently cited as explanations for the electronic industries' commitment to R&D. In recent years, however, the rate of growth in R&D spending in the electronic industries has declined. From 1980 to 1985, R&D spending increased an average of 17.0% per year, declining to less than 7.0% a year from 1985 to 1989.

Electronics R&D spending relative to that of other major industries is depicted in Figure 7-H, which shows company R&D expenditures and R&D/Sales ratios for six leading industries. The electrical and electronic equipment industries registered one of the top R&D/sales ratios in 1989 at 5.3%.

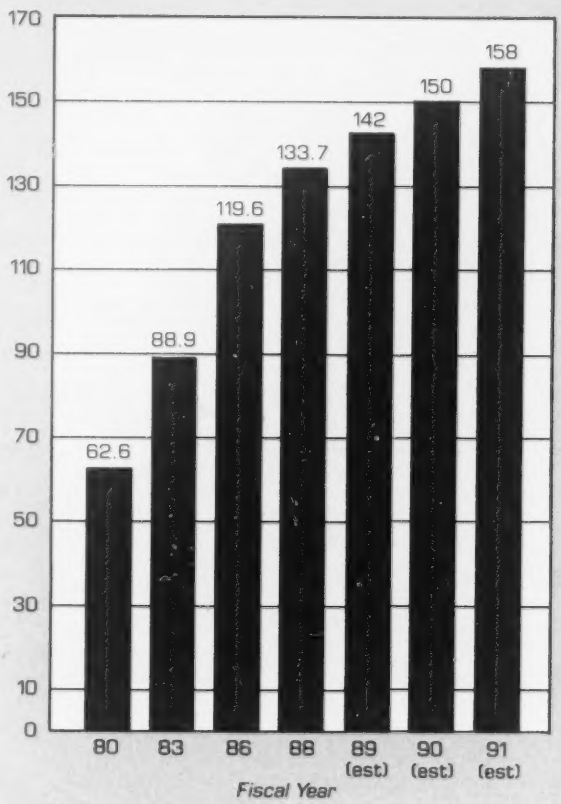
Federal Expenditures for R&D by Agency

The federal government has been the source of nearly one-half of the total expenditures for the nation's R&D in recent years. In 1990, this percentage was 44.0%. Total federal funds obligations by agency indicate that the largest single area of R&D spending in the federal budget is defense (Figure 7-G). In 1990, R&D allocations to the Department of Defense totaled $35.9 billion, with $36.9 billion allocated for 1991, by far the largest award to any government agency. The remaining portion of federal R&D monies is largely devoted to programs in health, environment, space exploration, and energy. Currently, about 20 agencies are awarded control of segments of the total federal budget for R&D. In 1990, federal fund obligations for defense were dominated by the major players: Air Force (39.3%), Navy (27.0%), and Army (15.8%) (see Figure 7-I).

R&D Scientists and Engineers

The most recent NSF survey available estimates 1.44 million scientists and engineers were employed in the R&D field in 1988. This figure represents approximately 25% of the total

National R&D Expenditures ($ Billions); United States, 1980-1991 FIGURE 7-F



SOURCE: National Science Foundation.

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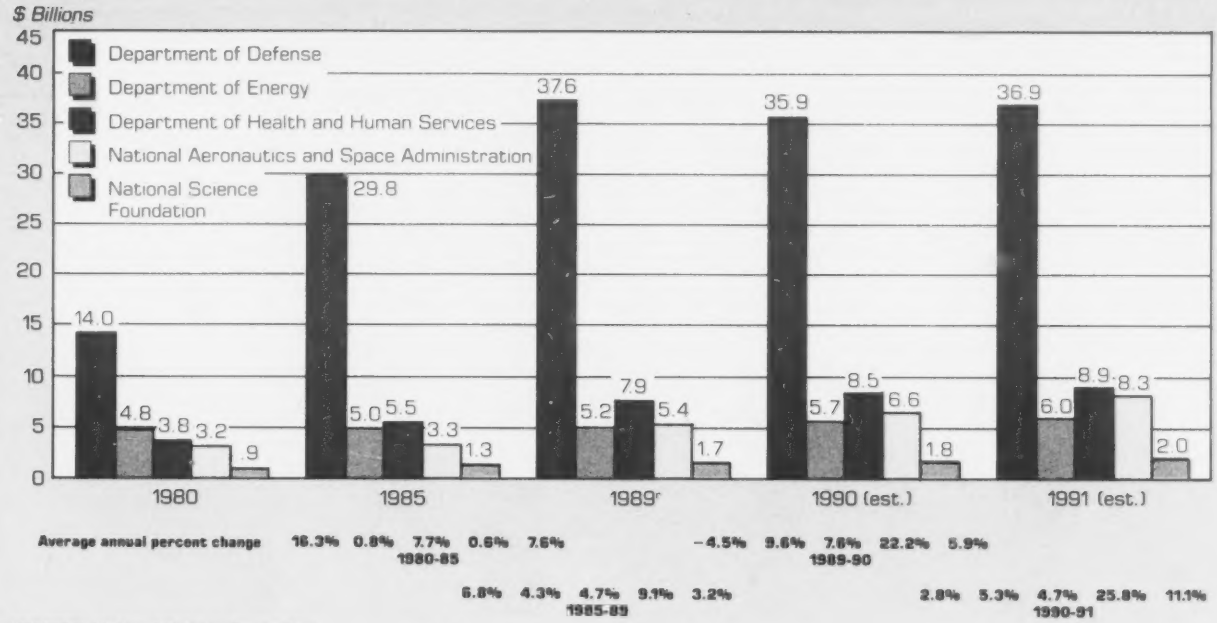
Federal R&D Obligations by Agency ($Billions); United States, 1980-1991

FIGURE 7-G

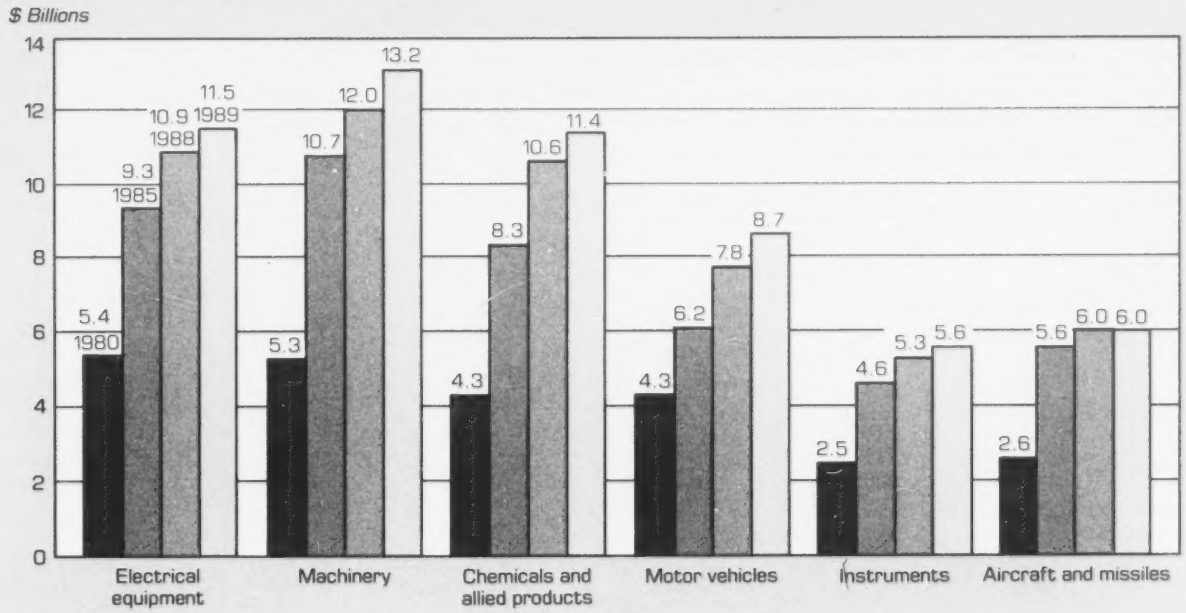


Average annual percent change	16.3%	0.8%	7.7%	0.6%	7.6%		−4.5%	9.6%	7.6%	22.2%	5.9%
			1980-85						1989-90		
				6.8%	4.3%	4.7%	9.1%	3.2%		2.8%	5.3%	4.7%	25.8%	11.1%
						1985-89						1990-91		

SOURCE: National Science Foundation.

Company R&D Expenditures and R&D/Sales Ratio of Six Leading Industries, ($ Billions); United States, 1980-1989

FIGURE 7-H



R&D/sales ratio																		
	3.9%	4.8	5.2	5.3			3.3%	4.9	5.3	5.3			6.1%	8.3	7.3	7.2		
					4.5%	6.7	7.2	7.8			4.2%	3.1	3.4	3.8			3.8%	3.9	3.6	3.6

SOURCE: National Science Foundation.

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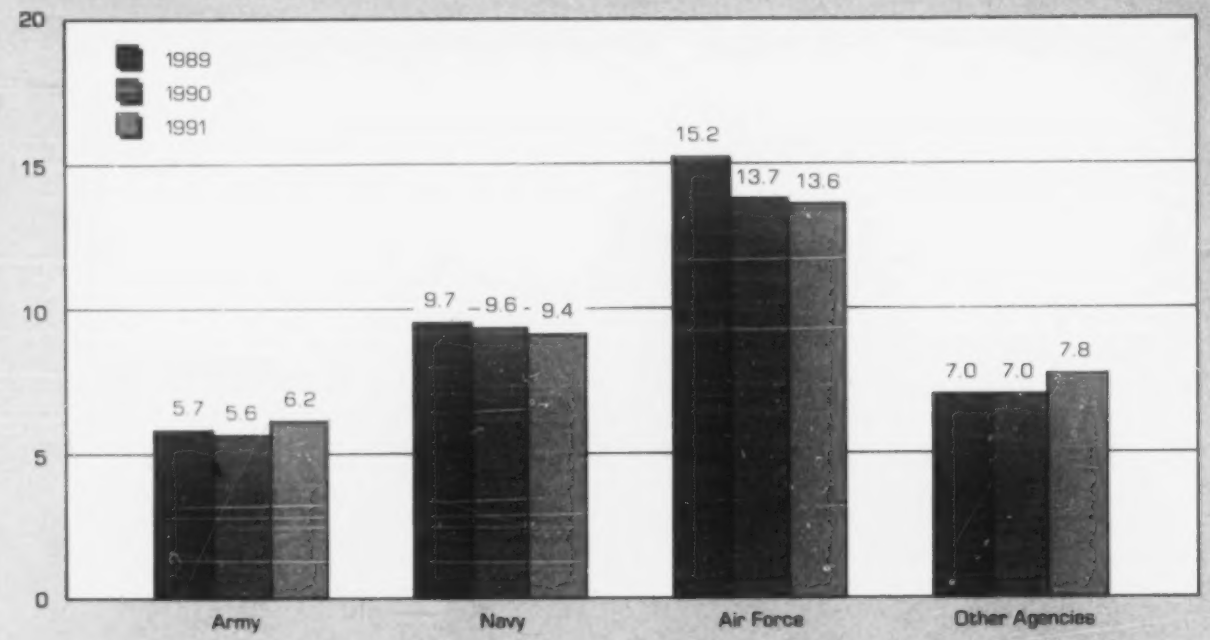
Department of Defense Obligations[1] for R&D by Agency, (Billions of Dollars); 1989-1991

FIGURE 7-I



[1]Values for 1990 and 1991 are estimates.
SOURCE: National Science Foundation.

Company R&D Funds ($ Millions), R&D/Sales Ratio[1], 1985-1989

TABLE 7-9

INDUSTRY	1985	1986	1987r	1988r	1989
Office, Computing & Accounting Machines (SIC 357)					
Company R&D Funds	8,418	8,380	8,193	9,371	10,533
R&D Sales Ratio (%)	12.4	12.4	12.3	11.5	13.4
Radio & TV Receiving Equipment (SIC 365)					
Company R&D Funds	350	133	139	139	85
R&D Sales Ratio (%)	3	3.6	3.2	3.0	2.9
Communications Equipment (SIC 366)					
Company R&D Funds	5,147	5,117	5,455	5,675	5,842
R&D Sales Ratio (%)	5.4	5.2	5.5	5.4	5.4
Electronic Components (SIC 367)					
Company R&D Funds	2,826	3,357	3,630	3,879	4,362
R&D Sales Ratio (%)	8.2	9.2	8.5	8.0	8.3

[1]Company R&D Funds as a percent of net sales.
r-Revised.
SOURCE: National Science Foundation.

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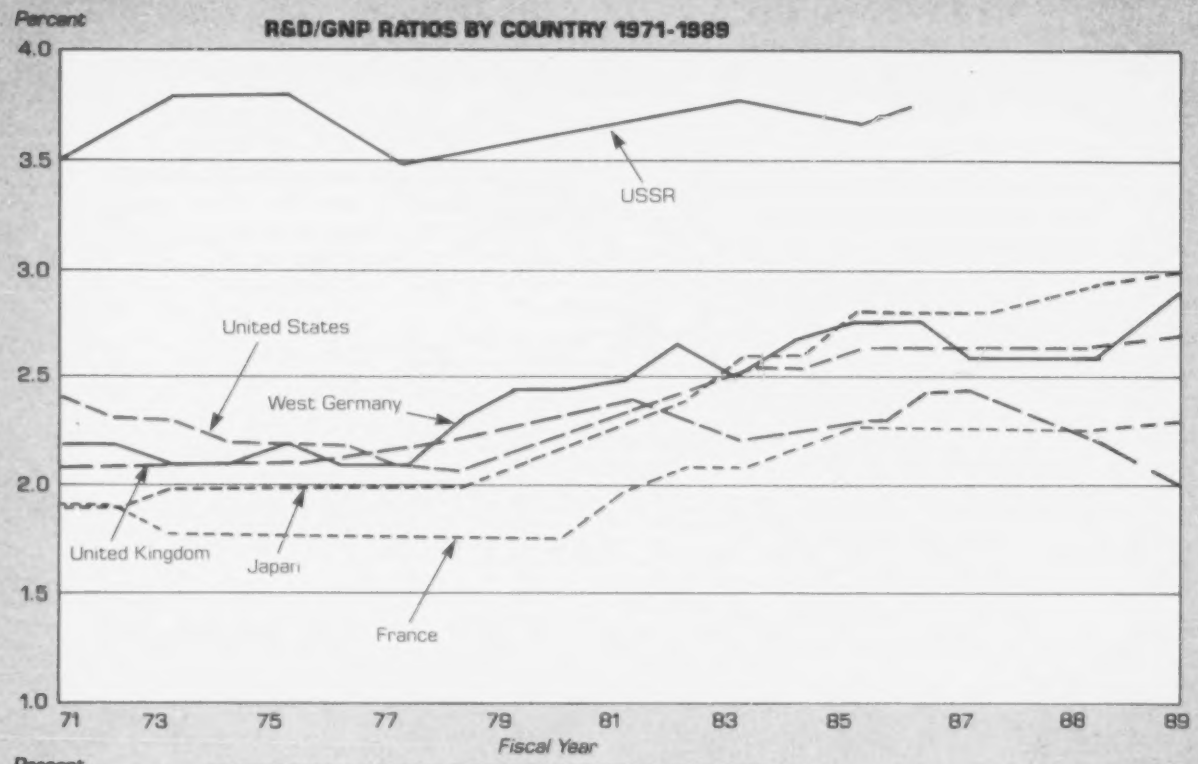
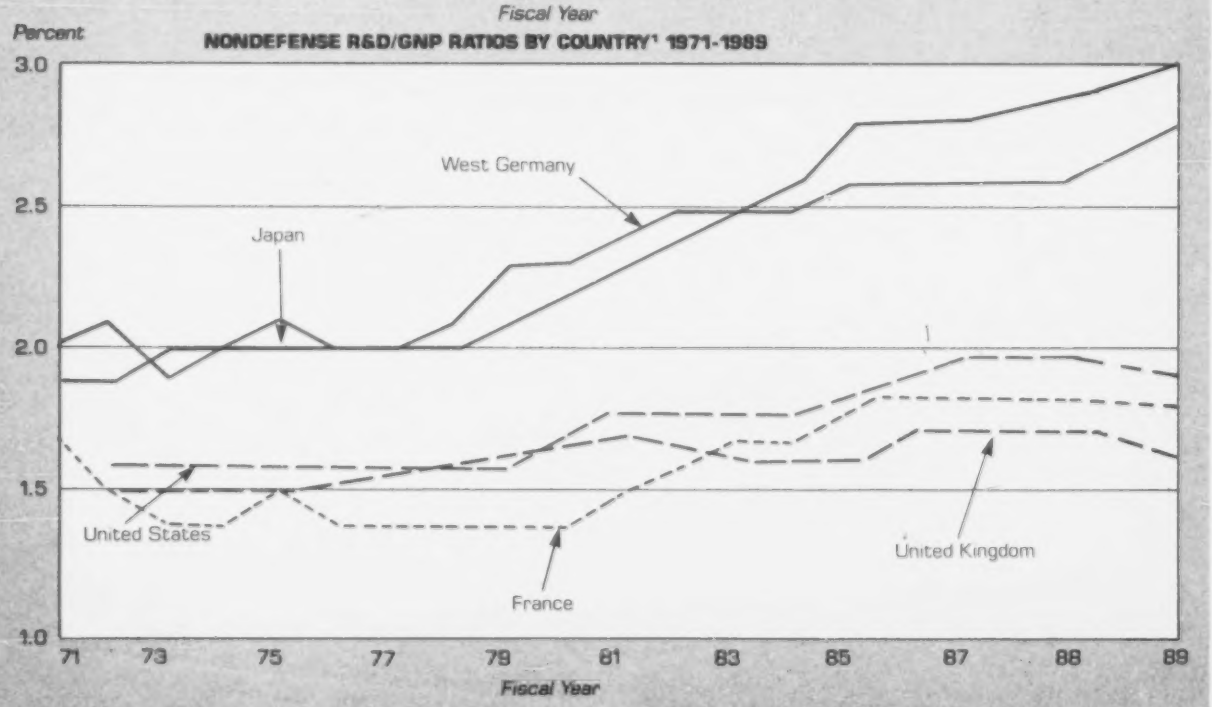
R&D/GNP Ratios by Country, 1971-1989

FIGURE 7-J





[1]Separate data for nondefense R&D in the U.S.S.R. not available.
SOURCES: National Science Foundation and Organization for Economic Co-operation and Development.

employed scientists and engineers in the United States (Figure 7-E). Of the 2.6 million scientists employed in the U.S. in 1988, approximately 21% were engaged in R&D. R&D engineers comprised 33% of the 2.7 million engineers employed in 1988.

R&D Expenditures by Country

The relative importance that countries place on R&D can be observed by comparing R&D expenditures as a percentage of a country's gross national product (GNP). It has been effectively argued that the percent of GNP allocated to R&D is positively correlated with the level of future productivity.

During the 1960s, the United States had the highest R&D/GNP ratio of the major industrialized countries at nearly 3.0%. By 1971, this ratio had declined to 2.4%, while those for the U.S.S.R., West Germany, and France were increasing (Figure 7-J).

During the mid-1970s, total R&D spending by the major industrialized nations leveled off. However, in 1978 there was an upturn in total R&D expenditures for all countries shown, which has continued through the mid-1980s, with the exception of the United Kingdom. From 1987 to 1988 the R&D/GNP ratios of the U.S., West Germany, and France remained flat, while that of Japan grew to nearly 3.0%.

As shown on the lower graph of Figure 7-J, non-defense R&D expenditures as a percentage of GNP indicate that the United States's historical R&D/GNP ratios are lower than those of West Germany and Japan. The United States, with its major international defense obligations, devotes a majority of government R&D funds to defense (see Figure 7-J), while both West Germany and Japan are legally restricted in their defense-related R&D outlays. Consequently, in both countries, the R&D effort is primarily civilian-oriented, supporting the dominant place each country has in the world economy.

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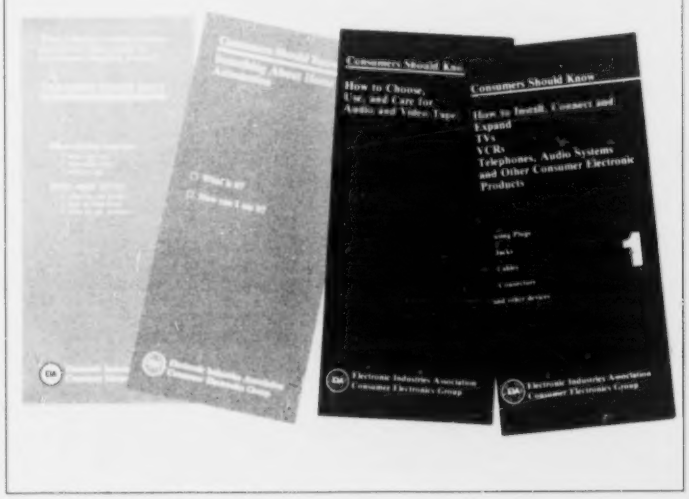
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VCRs
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1
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Glossary of Terms

The following glossary defines many of the acronyms and government/electronic related terminology referred to in the preceding seven chapters of the *1992 Electronic Market Data Book*.

1990 Budget Enforcement Act—the 1991-1993 fiscal year federal budget agreement between the Administration and Congress negotiated in October of 1990 whereby defense spending and social spending became functionally separate budgetary areas. (Also referred to as the 1990 Budget Resolution.)

A-B test—direct comparison of the sound/picture quality of two pieces of audio/TV equipment, by playing one and then the other.

Accessories—devices for installation, storage, care, maintenance, and enhancement of consumer electronics products.

Acoustics—the science of sound.

Acoustic (or Air) Suspension—type of loudspeaker system that utilizes an air-tight sealed enclosure.

Active Components—amplify or modulate electrical signals, or rapidly switch voltages or currents to generate signals that can be stored (memory), added to, or subtracted from other signals (logic), and then transmitted.

Active-Matrix LCD—a type of flat-panel display; a reflective visual character readout device.

A/D;D/A—Analog to Digital, Digital to Analog conversion.

Adapter—a device that makes electric or mechanical connections between items not originally intended for use together.

ADIS—Advanced Driver Information System (automotive electronics).

AFC—Automatic Frequency Control; circuit which locks FM or TV receiver to station frequency. Sometimes called AFT (Automatic Fine Tuning).

AGC—Automatic Gain Control; minimizes picture differences with changes in strength of incoming signal (TV).

AHD—Audio High Density; system of digital audio recording on grooveless discs, employing an electronically-guided capacitance pickup.

AI—see Artificial Intelligence.

ALU—Arithmetic Logic Unit.

AM—Amplitude Modulation; the type of transmission used in the standard radio broadcast band, 550 to 1600KHz.

Analog—a continuously varying signal that takes the form of cycles or waves.

Analog recording—system of recording in which music is converted into electrical impulses which form "patterns" in the grooves of phonograph record masters or in the oxide particles of master tapes representing (or analogous to) musical waveforms.

ANSI—American National Standards Institute.

AOI—Automated Optical Inspection; part of computer-aided manufacturing to detect errors in multi-layer PC boards.

API—Application Programming Interface (standard).

APPC/APPN—Advanced Program to Program Communication (product-independent protocol), and Advanced Peer to Peer Networking (automatic routing and directory services for a network of systems).

Artificial Intelligence—a category of computer science that concentrates on developing computer systems that use symbolic, non-algorithmic methods of problem solving to emulate human intelligence.

ASIC—Application-Specific Integrated Circuit.

Assistive Devices—special devices, attached to personal computers, telephones, and other electronic equipment, that are designed to help differently-able people use the equipment more effectively in the workplace and at home.

ATE—Automatic Test Equipment.

ATMS—Advanced Traffic Management System.

ATF—Advanced Air Force tactical fighter.

ATV—Advanced Television System; utilizes a higher resolution than the 525 line NTSC standard.

Audiotext—voice-based systems which transmit information in the form of verbal reports.

Autosound Products—various autosound products are listed under specific product types, for example loudspeakers.

AVC—Automatic Volume Control; in radio, maintains constant sound level despite undesired differences in strength of incoming signal.

B-2—Stealth Bomber, designed to escape radar detection by opposing forces.

Bass reflex—type of loudspeaker system that uses a ported enclosure.

Baud—speed at which a computer or accessory can send or receive information over telephone lines. One operating at 300 characters per second is said to have a 300 Baud rate.

Beta—one of three standard VCR systems (Beta, VHS and 8mm).

Bias—in tape recording, the application of a high frequency signal to the tape to optimize its frequency response.

Bipolar ICs—a device which uses both negative and positive charge carriers.

Bit—*Bi*nary digit; a single information digit, 0 or 1, used in computers and data communications. (4 bits = a "nibble"; 8 bits = a "byte" or word.) Faster machines operate in 16-bit and 32-bit configurations.

BOC—Bell Operating Companies (from AT&T split). RBOCs are Regional BOCs.
Booster—amplifier stage of some autosound equalizers.
BRI—Basic Rate Interface; 144kb/s standard rate for communications devices.
Brilliant Pebbles—a subset of SDI system, currently in the R&D phase.
BWO—Backward Wave Oscillator; traveling wave device, used in microwave and radar applications.
C3I—Command, Control, Communications and Intelligence; generic nomenclature for such system to maintain troops or weapon interface.
Cable Ready—a TV or VCR capable of receiving all channels offered by cable TV, including midband and superband channels, without the converter box supplied by a cable company.
CAD/CAM/CAE, CIM—*C*omputer *A*ided *D*esign (CAD), *M*anufacturing (CAM), *E*ngineering (CAE), and Computer Integrated Manufacturing (CIM).
Caller ID—a service that allows telephone customers to view the telephone numbers of people calling them.
Camcorder—a one-piece video camera and integral VCR which may or may not include a tuner.
CARS—Cable Antenna Relay Services; microwave transmission systems usually used to bridge gaps between cable transmission systems.
Cassette—type of tape cartridge containing two reels.
CAT—Computerized Axial Tomography (as in CAT-scan); electronic scanning technique used in the medical profession, along with NMR (Nuclear Magnetic Resonance) and PET (Positron Emission Tomography).
Cathode Ray Tube—see CRT.
CATV—Community Antenna TV, of Cable TV; a system of distributing TV signals.
CB—Citizens Band; the portion of the Citizens Radio Service on the 27MHz band, used for consumer two-way communications.
CCITT—International Consultative Commission on Telephone and Telegraph; sets standards as an arm of the International Telecommunications Union.
CD—Compact Disc; a plastic disc containing a digital audio recording, which is played back, optically, on a laser-equipped player.
CD-I, CD-V—Compact Disc-Interactive; stores audio, limited video, text and graphics for interactive use between a controller and a TV set. CD-V (Compact Disc-Video) provides full audio/video plus text and graphics for interaction with a Personal Computer.
CD ROM—Compact Disc, Read-Only Memory; an input memory disc for computers that typically holds 550 Mbytes of data.
CEBus—The Consumer Electronics Bus is the EIA/Consumer Electronics Group (CEG) home automation standard. It allows products from different manufacturers to communicate with each other via various communication lines and transmission bridges.
Centrex—the generic name for a switching service offered by local telephone companies to business customers.
CFA—Cross-Field Amplifiers; part of a family of traveling wave devices, along with magnetrons, etc.
CFE—Conventional Forces in Europe Treaty. Designed to draw down troop strength and non-nuclear armaments.
Chrominance—portion of color TV signal representing colors.
CISC—Complex Instruction Set Computing; a power-consuming instruction format, normally used with mainframe computers. RISC (Reduced Instruction Set Computing) is the modern version used with PC's and workstations.
Circumnaural—a type of headphone that almost totally isolates the listener from room sounds.
Closed-circuit TV (CCTV)—TV system in which camera and receiver are linked by cable or microwave.
CMOS—Complementary Metal Oxide Silicon; a combination of N&P channel transistors.
Coaxial—cable in which one connector is in the center, insulation along its length from the other conductor which forms a shield outside; used for wide-band (TV) applications.
Coloration—deviation in the balance of musical sounds, audible as an accentuation of one or more parts of the audio spectrum—heavy bass, prominent mid-range, or exaggerated high frequency reproduction.
Common carrier business—the telecommunications services provided by local exchange companies and interexchange companies.
Compact system—a single manufacturer's complete sound reproduction system consisting of one main source unit and two or more separate enclosed speaker systems, packaged to sell as one unit.
Company brand products—those products produced and sold (or purchased to be resold) to a distributor or to a retailer for resale under the manufacturer's own brand name.
Component system—a single manufacturer's complete sound reproduction system consisting of four or more separate components packaged to sell as one unit (example: receiver, manual single-play turntable, and two speakers).
Concentrators—a device that feeds signals from several data terminals into a single transmission line.
Connector—a complete electric connecting device, consisting of a mating plug and receptacle for cables, or of mechanically mating flanges for waveguides.
Console television receiver—any television receiver with a design concept requiring placement of the unit directly on the floor without the use of an additional table, shelf, cart; or a unit having a console design concept for standard screw-in legs; or a non-mobile base including models merchandised as console.
Continuous loop—type of tape system in which a single reel is used within an endless loop of tape.
Convergence—orientation of three electron beams in a color TV picture tube or computer monitor, so they pass through the same hole in the shadow mask at the same time.
Converter—an auxiliary unit used with a television or radio receiver to permit reception of channels or frequencies for which the receiver was not originally designed, e.g., a cable converter.
Coupler—a component that transfers energy from one circuit to another.
CPE—Customer Premises Equipment; telecommunications and computer equipment as opposed to the equipment provided by the telephone company.
Crossover Network—an electrical device which channels all frequencies to their proper component speaker (eg. low frequencies to the woofer, highs to the tweeter, etc.)
CRT—a vacuum display tube in which an electron gun generates beams that are guided to a screen illuminating small red, green, and blue phosphor targets on the surface. This results in colors and images on the TV screen/monitor.

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CSAC—Council on Superconductivity for American Competitiveness; formed in conjunction with the Superconductivity & Competitiveness Act (PL 100-697, completed in 1989).
DAT — Digital Audio Tape; a recording media which requires the information to be converted into a series of pulses that are translated into binary code (intelligible to computer circuits) and stored on magnetic tape.
dB—Decibel; a measurement of two power levels. A typical use is in the "signal to noise ratio," where the higher dB level represents a higher quality of sound (freer from noise).
DBS—Direct Broadcast Satellite; a system utilizing a higher-powered satellite with smaller ground dishes.
DCS—Distributed Communications Systems; a voice/data private branch exchange (PBX), for example.
DDM—Distributed Data Management; a system of networking data control.
Demagnetizer—a device that removes magnetism generated in tape heads as a consequence of playback and recording activities.
Desert Shield—allied build-up of combat forces in the Persian Gulf.
Desert Storm—allied War Effort in Persian Gulf.
Digital—in displays, the use of digits for direct readout; in recording or computing, the use of a binary code to represent information; in communications, the type of information sent over lines or airwaves.
Digital Audio Tape—see DAT.
Digital Recording—a system of recording in which musical information is converted into a series of pulses that are translated into a binary code intelligible to computer circuits, and stored on magnetic tape or magnetic discs. Also called PDM—Pulse Code Modulation.
Diode—two-element receiving tube or semiconductor device.
DIP—Dual In-line Package; an integrated circuit in which the pins are located in "line" on either side of the chip.
Dipole—antenna fed from the center; name often applied to "rabbit ear" antenna.
Discrete—type of quadraphone sound reproduction in which the four original sound sources are routed directly to the respective loudspeakers without encoding and decoding. Discrete is also a components term that distinguishes between an integrated circuit and an individual (or discrete) semiconductor, such as a transistor.
Disk—a round piece of magnetic-coated flexible (floppy) plastic covered by a protective envelope, used to store data.
Display—a visual representation of electrical/mechanical functions via LED, LCD or fluorescent devices. Also called a readout.
DMTX—Digital Microwave Transmission systems.
DOD—Department of Defense.
DOE—Department of Energy.
Dolby—a system of noise/hiss reduction invented by Ray Dolby, widely used in consumer, professional, and broadcast audio applications.
DOS—Disc Operating System; a controlling software for computers.
DOT—Department of Transportation.
DRAM—Dynamic Random Access Memory; read/write memory in computers.
DSPT—Display Station Pass Through; allows a workstation to network as a peer with applications on other systems.
DSS—Decision Support System; modeling packages for rapid access and analysis of corporate information stores on centralized mainframes. EIS (Executive Information Systems) is a faster, more usable format for the DDS approach.
DTAD—Digital Telephone Answering Device.
DTL—Diode Transfer Logic; older component technology.
DTS—Digital Telecommunications Switching; newer digital version of switching.
Dubbing—playing a tape on one tape machine and recording (dubbing or copying) on a second machine.
Dynamic range—in music, the range of amplitudes from loudest passages to softest passages, expressed in decibels; the larger the figure, the more realistic or natural the sound.
ECC—Error Correction Code; data bits added to data streams for accuracy checking (e.g. even/odd parity check for 1's and 0's).
ECM—Electronic Counter-Measures; military use of microwave, radar (decoys).
ED-Beta—Extended Definition Beta-format VCR's. ED-Beta's separation of the luminance and chrominance signals during record and playback, a wider luminance bandwidth and the use of high density tape result in sharper, more vivid picture quality.
EDI/EDIFACT—Electronic Data Interchange/For Administration, Commerce & Transportation. A communications standard for data exchange.
EDM—Electric Discharge Machines; industrial control and automation devices.
EDTV—Enhanced or Extended Definition TV; involved advanced encoding and/or transmission techniques, but having less resolution than HDTV. Also called EQTV (Enhanced Quality TV).
EIS—see DSS.
Electron gun—device in TV picture tube, or display device, from which electrons are emitted toward the screen.
EMI—ElectroMagnetic Interference; electric, electronic or magnetic interference with signals.
EOS—Earth Observing Systems program; a high-tech protocol to answer scientific questions regarding planet earth.
EPROM/EEPROM—Erasable, Programmable Read-Only Memory; a semiconductor device whose memory can be erased by ultraviolet light (slowly) or electrically (faster).
Equalization—frequency manipulation to meet the requirements of recording; also the inverse manipulation in playback to achieve uniform or "flat" response. Also called compensation.
ESP—Electronic Still Photography; single-frame video camera recording on a disc.
ESS—Enterprise Solutions & Standards; (e.g. UNIX) an operating system to simplify changing hardware/software formats via standards, support, and training.
Ethernet—a network protocol, where all stations are connected to the same bus. Only one station can transmit at a time, but all can receive. (Ethernet is a Xerox trademark.)
FDDI—Fiber Distributed Data Interface; a standard for 100 Mb/s transmission on Fiber Optic Local Area Networks, etc.
FEA—Finite Element Analysis; a computer aided design, manufacturing analysis of stress, thermal, magnetic, fluid flow, and displacement elements.
Ferri-chrome—a tape combining a layer of ferric oxide particles and a layer of chromium dioxide particles, for the attributes of both.
FFT—Fast Fourier Transform; a determination of the frequency content of an analog signal.

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Fiber Optic Cable—an assemblage of transparent glass fibers all bundled together parallel to one another.
Field—one half (every other line) of a TV picture "frame"; there are 60 fields per second in American TV.
Flash Technology—the latest technological trend in semiconductors; these devices are small, light, durable, and power-efficient methods of long-term information—able to erase old information and store new data in a flash.
Flip-flop—a digital storage device for a 0 or 1 bit.
Flops—often referred to as mega-flops or giga-flops, these are *fl*oating *op*erations per *s*econd, used to describe the speed and power of computers.
FM—Frequency Modulation; less susceptible to interference than AM. FM broadcast band covers 88 to 108 MHz.
FOG-M—Fiber Optic Guided Missile; military use of fiber optic technology.
Force-Sensor Technology—adapted into resistors, they are two-layer devices, with one layer of polymer, upon which are affixed a set of interlocked metal strips; the other layer of plastic sheet is coated with a semiconducting ink.
Frame—one complete television picture; there are 30 per second.
Frequency response—the total range of frequencies that can be reproduced by audio components, the wider the better. Human hearing is generally limited to the 20 to 20,000 Hz range.
Frequency synthesized tuning—tuning method that employs a reference quartz crystal oscillator for exceptional tuning accuracy—often better than .003%.
Front end—tuning, or radio-frequency, section of a radio or TV set.
Fuzzy Logic—a type of computer logic that deals with problem-solving using imprecise information.
FY—Fiscal Year.
GaAS, GaA/As—Gallium Arsenide/Gallium aluminum Arsenide; a semiconductor compound used in conjunction with silicon for chips.
Gate, Gate Array—an integrated circuit with a large number of input/output gates. Can be programmed.
GATT—General Agreement on Tariffs and Trade; presently on the Uruguay Round of multilateral negotiations focusing on intellectual property, services, delineation of non-tariff barriers, and agriculture.
GDSID—General Data Stream Identifier; used in communications systems.
GHz—see Hertz.
Graphic equalizer—a device that permits altering the tonal balance of an audio component system at several frequency levels, usually from 5 to 12.
Harmonic distortion—distortion that occurs when an audio component adds unwanted overtones to the original music tones.
HDTV—High Definition TV; High resolution TV, incorporating 1000 or more horizontal lines of resolution, wide aspect ratio and digital quality radio.
Head—the device in a recorder which makes contact with magnetic tape and converts magnetism to electrical signals or visa versa.
Headphones—very small sound reproducers (miniature loudspeakers) designed for wearing around a person's head or in a person's ears.
Headset Portable Audio Equipment—portable audio tape equipment or radio/tape combination equipment intended for use primarily with headsets, earphones, or headphones.
Hertz (Hz)—the unit of frequency equal to one cycle per second (cps); one kilohertz (KHz) = 1000 cps; one megahertz (MHz) = 1 million cps; one gigahertz (GHz) = 1 billion cps.
Home Automation—see CEBus.
HUD—Department of Housing and Urban Development.
Hue—color set control governing color values in TV picture. Also called tint.
IBC—Interactive Business Computer; built for networking.
IC—Integrated Circuit—a combination of interconnected circuit elements combined on a base material (e.g., silicon) capable of performing a circuit function in an extremely small size (also referred to as integrated microcircuits).
ICBM—Intercontinental Ballistic Missile.
IDTV—Improved Definition TV; Intermediate system designed to improve resolution of existing NTSC standard without involving new transmission standard. Less resolution than EDTV and HDTV.
IEC—International Electrotechnical Commission; a group that sets standards for industrial controls. The standards apply to foreign machinery in the U.S. as well.
IF—Intermediate Frequency to which a signal is shifted within a receiver for amplification.
IM—Intermodulation (distortion) caused when both high and low frequency tones in music intermodulate with each other. Expressed as a percentage (low is better).
Image Enhancer—a device that improves color television pictures by comparing each video line, element by element, with the preceding and following lines. Any differences between vertically aligned elements are added to the middle-line element in the proper phase to enhance picture outlines and contrast.
INA—Information Networking Architecture; networking configurations that conform to standards.
INF—Intermediate Nuclear Forces Treaty (signed in the late 1980s) involving the reduction and eventual elimination of U.S. Pershing missiles based in Europe and Soviet SS-20 short-range missiles intended for use in the European Theater.
In-line—color picture tube in which the electron guns are side-by-side, as opposed to the conventional triangular arrangement.
INMS—Integrated Network Management Systems; operating systems for entire networks of data handling and communication.
Integrated Amplifier—a pre-amplifier and power amplifier combined in one single integrated chassis.
Integrated Microcircuits—see ICs.
Interface cards—a device at which a transition between media, power levels, mode of operation, etc., is made.
IPS—Inches Per Second; measurement of tape speed.
IR, or Infrared remote control—a system of controlling audio/visual equipment from a distance without wires. It utilizes infrared radiation to transmit the control information to a given piece of equipment.
IRCC—International Radio Consultative Committee; also used to describe 625-line TV system used principally in Western Europe.
ISDN—Integrated Services Digital Network; standards for a digital network of hardware, software, and communications links.
ITV—Instructional TV or Industrial TV.

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ITFS—Instructional TV Fixed Service: a fixed station operated by an educational organization and used primarily for the transmission of audio-visual instructional, cultural and other types of material to one or more stations.
IVHS—Intelligent Vehicle Highway System: computer technology applied to automobiles and transportation systems.
JESSI—Joint European Submicron Silicon Initiative: an 8-year program involving private companies and governments aiming for a world-competitive status for the European semiconductor industry.
JISIA—Japan Information Services Industry Association: a software group.
JIT—"Just-In-Time" arrival of components from vendors to manufacturers. This requirement forces inventories back on suppliers, and with it, more inventory control techniques.
Key Systems—multi-line business communications systems providing users with shared access to a group of external telephone lines.
Kinescope—Picture tube.
LAN—Local Area Network: a connection of several computers and workstations.
Laser—Light Amplification by Stimulated Emission of Radiation.
Laserdisc Player—a device which has the ability to process digital signals from optical discs to reproduce digital video in combination with stereo sound (laser video) and may be capable of playing both digital audio compact discs and 8" and 12" laser video discs (combi-player).
Laser-optical—system of video recording on grooveless discs, employing a laser-optical-tracking pickup.
LCD—Liquid Crystal Display: a system of readout for digital watches, calculators, TV screens and computer displays using reflected (or non-reflective) light via electrical stimulation.
LED—Light Emitting Diode: a semiconductor which lights up when activated by a voltage, used in readout displays and a variety of consumer and commercial products.
Lead-in—wire or cable from antenna to TV set.
Limited Defense System—ground-based defense providing highly effective defense of the contiguous 48 states plus Alaska and Hawaii against a multitude of missile attacks.
Linearity—the straightness of a frequency response curve as an indication of true or accurate sound reproduction.
Liquid Crystal Display (LCD) TV—a television which does not incorporate a CRT, but rather a liquid having the characteristics of crystals, including double refraction and interference colors.
LISP—List Processing: an older computerized process in Artificial Intelligence.
LM—Laser Machines: used in industrial automation applications.
LOSAT—Line Of Sight Antitank Program: defensive system for protection against tanks.
LSI—Large Scale Integration: an integrated circuit with between 100 & 1000 gates.
Luminance—brightness, or monochrome, element of broadcast color TV signal.
MAN—Metro Area Network: a company's own network, as an alternative to local carriers (telephone companies).
Matching Transformer—a transformer used between unequal impedances for matching purposes, to give maximum transfer of energy.
Matrix—type of quadrophonic sound system in which four channels are encoded into two channels for recording or broadcast, then decoded into four channels by consumer equipment. The term is also used in displays (see active matrix).
MDA—Manufacturing Defect Analyzer: a component of Automatic Test Equipment.
Memory—device or circuit to hold machine-language in electrical or magnetic form.
MHz—see Hertz.
Micro-cassette—miniaturized version of the standard audio cassette.
Micro components—small audio components that provide the benefits of traditional-sized components in far less space.
Microelectronics—the applications of miniaturization techniques to the design and construction of electronic equipment.
Microphones—electrical devices used for recording, which convert sound into electrical signals for consumer use only.
Microprocessor—the primary semiconductor chip inside computers and other digital devices.
Midrange—speaker designed to reproduce notes between treble and bass.
MIPS—Millions of Instructions Per Second: a measure of computer speed.
Missile Defense Act of 1991—requires partial deployment of anti-ICBM force by 1996, or as soon as practicable.
Mixer—a component which blends or "mixes" two or more audio signals together during recording; includes both microphone and turntable mixers.
MMI—Man-Machine Interface: a software and operating system and devices.
Modem—*Mo*dulate/*Dem*odulate: a device that connects computers and other data transmission devices to a network (e.g., a phone line).
Monaural—system in which sound is delivered over only one channel.
Monopole—single-rod indoor TV antenna.
MOS, MOSFET—Metal Oxide Silicon (as opposed to bipolar) IC's; FET = Field Effect Transistor. An IC in which the gate electrode is isolated from the channel by an oxide film.
MSI—Medium Scale Integration: an integrated circuit with between 13 & 100 gates.
MSS—Mobile Satellite Systems: dishes and equipment that allow vehicles to communicate with and be tracked by a central location.
MTS—Multichannel TV Sound: the initials MTS are commonly used to designate TV, VCR, and adapter tuners equipped for stereo signals. A Separate Audio Program (SAP) channel also exists for simultaneous audio (or other) use.
MTS-Capable—a television receiver or VCR with a built-in MTS (multi-channel television sound) decoder, whether for stereo sound and/or second audio channel.
Multichannel, multipoint distribution service (MMDS)—see Wireless Cable.
Multiplex—superimposition of two separate signals on a single broadcast channel (as in FM stereo) or on a single wire/cable for data transmission.
MYP—Multi-Year Procurement: a purchasing procedure used by the government that often applies to government electronics systems.
NAMSRC—National AM Stereo Radio Committee.
NASA—National Aeronautics and Space Administration.
NATA—North American Telecommunications Association.

Negative guardband—color picture tube in which holes in the shadow mask are slightly enlarged and phosphor areas slightly reduced, insuring that each phosphor area is fully illuminated by the electron beam for greater brightness.
Negative Matrix—combination of negative guardband and black matrix—Picture Tube in which the color phosphors are surrounded by black for increased contrast.
NES—National Energy Strategy; current Administration policy for all forms of energy manufacture, consumption, and clean-up.
Neural Network—a system of interconnected processing units, patterned after neurons in the human nervous system, that sometimes can be self-organizing and capable of "learning."
NICs—Newly Industrialized Countries.
NLOS-FAAD—Non-Line Of Sight Forward Area Air Defense; on-board fiber optic system for guided missiles (see FOG-M).
NMR—Nuclear Magnetic Resonance; medical electronics used for diagnosing and monitoring diseases without X-rays.
Node—a central switching system that routes information from original points to destinations in LANs, etc.
Noise Reduction Unit—a device which can be added to an output unit to limit the noise in the circuit and thereby improve the signal-to-noise ratio.
NTP—National Transportation Policy; current Administration policy for air, rail, and surface transportation needs.
NTSC—National Television System Committee; applied to U.S. systems of color and monochrome TV broadcasting.
O&M — Operations and Maintenance; fully deployed systems for troop use.
OCR—Optical Character Recognition; devices used in scanning, image processing and text recognition.
OEM—Original Equipment Manufacturer; buyers of components for their own assembly. Also buyers/providers of finished goods for different marketers.
OLTP—On-Line Transaction Processing; electronic banking, for example.
Open-air—type of stereo headphone that offers "private" listening capability but does not totally shut off sounds within the listening room.
Oscilloscope—a test instrument used in electronic circuit and device design, circuit diagnosis, equipment maintenance, and product manufacture.
OSI—Open Systems Interconnect; a protocol model promoted by International Standards Organization (ISO).
OSS—Operating Support Systems; software support for networks.
PAD—Packet Assembler/Disassembler; a converter for transmitting bundles or packets of data. The generally accepted protocol is X.25.
PAL—Phase Alternate Line; color TV system adopted by most Western European countries. In components, PAL stands for Programmable Array Logic. The device that contains the logic is called a PLA (Programmable-Logic Array).
PAM—Plasma Arc Machines; part of a family of industrial automation machines.
Passive Components—carry electrical signals from one active component to another; turn them on or off; tune electrical circuits; raise or lower voltages; or limit current flows.
Patch Cable—a cable equipped with plugs at each end to connect two jacks on a patchboard.
PBX—Private Branch Exchange; the company premises telephone switching equipment.
PCM—Pulse Code Modulation; the binary version of an analog signal.
PDS—Premises Distribution System; local networks for voice/data.
Personal Communications Network (PCN)—a wireless personal communications network which utilizes microcell technology to enable users to communicate with base stations.
Personal Communications Service (PCS)—Communications services provided through Personal Communications Networks (PCNs).
Phosphor—substance that glows when struck by electrons, used to coat the inner surface of a picture tube.
Pitch control—variable control for increasing or decreasing the speed of a tape deck or turntable. "Pitch" is also a measurement of picture tube internal tolerance.
Pixel—the smallest point in a display.
PLC—Programmable Logic Controller; used in industrial controls.
PMA—Physical Media-Dependent; a standard for communication interface.
Polyamide, polymer, polypropylene—synthetic materials used for speaker cones, noted for light weight, minimum resonance, and the proper elasticity-rigidity for fast transient response.
Portable Audio Tape Equipment—audio tape equipment capable of battery operation; that is, AC/DC or DC only, using C-size or micro-cassettes.
Power Amplifier—the second or final stage of an amplifier system, which regulates and increases low-level signals received from the pre-amplifier and feeds them to speakers.
Power Supply—a circuit that converts alternating current (AC) to direct current (DC) power.
Pre-Amplifier (also known as Control Center)—the first stage of an amplifier system, which boosts the amplitude of a weak signal from a source (tuner, turntable, tape deck, CD player) and/or provides for tonal adjustment so that the signal may be fed into a power amplifier. Usually contains all audio controls.
Preset—the "programming" of radio station frequencies in a tuner or receiver, or musical selections on tape, for instant recall at the push of a button.
PRI—Primary Rate Interface; a communications integrated system standard (1.544Mb/s) for transmission.
Private Brand Products—those products produced and sold to another manufacturer, distributor, or retailer for sale under a brand name other than that of the original manufacturer.
Private packet switching—a data communications service that increases the capacity of telecommunication networks by enabling a single channel to be used for multiple concurrent transmissions.
Projection Television—any indirect-view television receiver. Unless otherwise specified, projection television is not included in color television statistics.
PROM—(one-time) Programmable Read-Only Memory; to store digital codes.
PSTN—Public Switched Telephone Network; Telco network.
Rack System—a single manufacturer's complete sound reproduction system, including a rack or cabinet, packaged to sell as one unit. May be a compact or component system.
RAM—Random Access Memory; used by a computer to store and manipulate information.
RBOC—Regional Bell Operating Company.
RDT&E—Research, Development, Test, and Evaluation.

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Receiver—a three-way integrated component consisting of a tuner, pre-amplifier, and power amplifier.
Receiver Combination—a receiver incorporating an additional function or component such as a cassette deck.
Remote Control—a device which permits control of electronic equipment from a distance.
RF—Radio Frequency.
RISC—Reduced Instruction Set Computing; a standard language for PC's and workstations in networks.
RMS—Root Mean Square; method of measuring amplifier power.
ROM—Read-Only Memory; media pre-programmed with information. A computer's built-in ROM contains operating instructions. Plug-in ROM cartridges are used in video games, and Compact Discs include ROM for input into computers.
RV—Reentry Vehicle.
SAP—see MTS.
SCSI—Small Computer Systems Interface; a standard for disc drive/controllers.
SDIO—Strategic Defense Initiative Organization; to develop a space based anti-ballistic missile for the U.S.
SDLC—Synchronous Data Link Control; standard interface between LANS and wide-area networks (WANS).
SECAM—Sequential and Memory color TV system adopted by France and other Eastern European and Middle East countries.
Selectivity—ability of a tuner or receiver to select a desired station while rejecting other adjacent stations. The higher the decibel reading, the better the selectivity.
Self-healing rings—fiber optic loops that help protect against telecommunication network breakdowns; used in MANS.
Sensitivity—the input signal level required by a tuner, amplifier, etc., to be able to produce a stated output. The lower the necessary input, stated in MV (microvolts), the higher the sensitivity.
Separation—extent to which two stereo channels are kept apart; expressed in decibels; the higher the number, the better the separation and stereo effect.
Shadow mask—color picture tube in which the electron beam is directed through a perforated metal mask to the desired phosphor color element. Two similar perforations are the slits and slots, as opposed to round holes.
Shortwave Radio—a radio which may or may not be multiband, which operates on a bandwidth from 1.6 to 3.0 MHz.
SM, SMD, SMT—Surface Mount, SM Devices, SM Technology; a miniaturization technology of soldering directly to copper pathways on PC boards without holes, wires, or leads.
SMART—Surface Mount & Reflow Technology; the technology of interconnecting and packaging electronic circuits. EIA and IPC (Institute for Interconnecting and Packaging electronic circuits) hold "SMART" conferences to advance standards.
SMRS—Specialized Mobile Radio Systems.
S/N—Signal to Noise ratio; ratio between a component's output signal intensity and its accompanying noise content, expressed in decibels—the larger the number, the better.
SNA, SNADS—System Network Architecture, SNA Distribution Services.
Solid State—commonly used to indicate use of semiconductor devices vs. tubes.
SONET—Synchronous Optical Network; a standard for fiber optic and optic-related equipment.
Sound Processor—a component such as an expander and time delay or ambience restoration device. Excludes equalizers and noise reduction units.
Space Station Freedom—anticipated test bed for manned space experiments (the deployment date has been continually rescheduled).
SPARC—Scalable Processor Architecture.
Speaker—a device which converts electrical energy from the power amplifier into sound energy through a variety of different types of transducers (speaker components, e.g., woofer, tweeter, etc.)
SPL—Sound Pressure Level; loudness level of a speaker relative to a specified output signal, stated in decibels.
SRAM—Short Range Attack Missile; nuclear armed, inertially guided attack missile, carried by B-52, B-1, FB-111A and B-2 bombers.
SSI—Small Scale Integration; IC chips with 1-12 gates.
START—Strategic Arms Reduction Treaty; to draw down ICBMs nuclear warheads, long-range delivery systems and forces.
Stereo Decoder—a device which enables television receivers or VCRs without integral MTS capability to receive and reproduce stereo sound and/or a second audio channel.
Stereophonic or Stereo—system in which sound is delivered over two or more channels.
Surface Mount International Exposition and Conference, The—a joint show and conference by EIA, Interconnecting Packaging Electronic Circuits (IPC), Surface Mount Technology Association, and Miller Freeman Exposition Company; this is a comprehensive show and conference for engineering executives involved with SMT. The first Surface Mount International was held August 1991, in San Jose, California.
Surround Sound Processor—a component which incorporates a signal decoder device and has the ability to produce multi-channel sound from a monaural or stereophonic two channel source. It may also enhance the sound through techniques such as time delay.
S-VHS—Super VHS; separation of the luminance and chromanance signals, a wider luminance band width and the use of high density tape provide 400 lines or better, compared to 240 lines (resolution) of a standard VHS VCR.
T1, T3—time division multiplexer links; T1 integrates voice, data video, fax, and graphics in a 1.5 mb/s speed; T3 (DS3) sends at a 45 mb/s rate.
TAD—Telephone Answering Device.
TCP/IP—Transmission Control Protocol/Internet Protocol; two protocol standards for sending and connecting data systems.
TCE—Thermal Coefficient Expansions.
TDM—Time Division Multiplex; backbone network for volume data transmission.
TENS—Transcutaneous Electrical Nerve Stimulation; medical electronic technology.
THD—Total Harmonic Distortion; harmonic distortion created by an audio component, expressed as a percentage—the lower the better.
Time delay—audio circuitry that provides a delay before initiating an output signal to create an acoustical result, e.g., a "studio" or "concert hall" ambience.
TMD—Theater Missile Defense.
Token, Token Ring—the bit pattern of a ring network to determine if transmission ring is free or busy.

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Transducer—a device that converts one type of energy (electrical, acoustical, magnetic, mechanical) into another.
Transistor—active semiconductor device with three or more electrodes.
Transmission "Cells"—a limited area where low powered transmissions are available.
TRON—The Real-time Operating Nucleus: a Japanese standard Operating System for connecting various micro systems into a network.
TT&C equipment—Tracking, Telemetry and Control equipment used to manage satellite communications.
TTL—Transistor to Transistor Logic: back to back bipolar transistors (high Speed).
Tuner—portion of a radio or television set to select the desired incoming signal.
TVRO—TV Receive-Only: typically, a large satellite dish.
Tweeter—a high frequency (treble) loudspeaker.
Twin lead—standard 300 ohm TV or FM lead-in wire (ribbon).
TWT—Traveling Wave Tubes: continuous wave devices for microwave, radar uses.
UHF—Ultra High Frequency: TV channels 14 through 83.
UPS—Uninterruptible Power Supply: back-up protection for computers and communications systems.
VAN—Value Added Networks: services provided to enhance LAN links, usually where nodes are more than 200 miles from the central headquarters.
Varactor—variable-capacitance diode used in electronic tuning systems for TV and radio: hence the name "varactor tuning."
Vernier tuning—continuous-type fine tuning.
VGA—Video Graphics Array: a computer and monitor display designed for graphics.
VHD—Video High Density: system of video recording on grooveless discs, employing an electronically-guided capacitance pickup. (Not in U.S. market now).
VHF—Very High Frequency: TV channels 2-13.
VHS—Video Home System: one of the standard home VCR systems (Beta, VHS, 8mm).
VHSIC—Very High Speed Integrated Circuit.
Videocassette—video tape package in cassette or cartridge form.
Videocassette Player (VCP)—a magnetic tape device that can play, but not record, videocassettes.
Videocassette Recorder/VCR Deck—a magnetic tape recording device which records both video and audio information simultaneously on one magnetic tape cassette, with an integral, inseparable television tuner.
Video dial tone—an idiom for service which will allow RBOCs to deliver video signals through telephone lines.
Video-on-demand—an interactive TV service which allows users to retrieve programming at their convenience.
Videoconferencing—simultaneous use of video and audio by which entire groups can interact without leaving their offices.
Video Tuner/AMP Combination—a device which receives television broadcast signals for display of the video signal on a video monitor and for reproduction of the audio signal: does not require a separate amplifier.
VLSI—Very Large Scale Integration: IC chips with 1000 or more gates.
VSAT—Very Small Aperture Terminal: ground station equipment for point-to-multipoint and other combinations of satellite communication applications.
VTR—Video Tape Recorder: Broadcast use may involve reel-to-reel devices.
VU meter—Volume Unit indicator: used to show volume level in tape recording. Also has industrial applications.
WAN—Wide Area Network: communication network designed to cover a large geographic area, often linking LANs.
Wireless cable—microwave transmission of television programming.
Woofer—low frequency (bass) loudspeaker.
WORM—Write Once, Read Many: optical disc for storing data (record, but not erase).
Wow—sound distortion resulting from slow irregularities in the rate of speed of a record or tape recording.
Zoom Ratio—the longest focal length divided by the shortest in a camcorder.

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The EIA Government Division consists of companies who manufacture or engage in research or development of systems, subsystems, electronic end equipment, assemblies and subassemblies for use by any agency of the government. Membership also includes companies who provide operations, maintenance, and support services to government agencies. Currently, over 95 percent of the $40 billion defense electronics market is represented by the members of the EIA Government Division.

Administration

The Division's Washington-based staff is in constant touch with key representatives of DoD and other Government agencies, Congress, and other EIA elements, and related associations and societies. In this capacity, the staff monitors and analyzes, organizes for action, and disseminates information on developments which impact government contractors.

Organization

The Division is governed by a Board of Directors composed of a senior executive from each member company. The Board sets policy for the division and meets several times during the year to ensure that industry's financial and manpower resources in the Division programs are continually responsive to its changing needs. Ten representatives of the Division serve on the overall EIA Board of Governors. The Division operates largely through a council and committee structure.

Membership Dues

Annual dues in the EIA Government Division are based on sales of defense electronic systems and equipment.

For further information on membership in the EIA Government Division, contact: Dan C. Heinemeier, Vice President, Government Division, Electronic Industries Association, 2001 Pennsylvania Ave., NW, Washington, DC 20006. (202) 457-4941

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EIA: Serving the Electronic Industries

The Electronic Industries Association (EIA) is the full-service national trade organization representing the full spectrum of electronic manufacturers in the United States. Its members range from manufacturers of the smallest electronic part to corporations that design and produce the most complex systems used in defense, space and industry.

Originally founded in 1924 as the Radio Manufacturers Association, EIA, through its 68 years of service to the electronic industries, has maintained a quick reaction capability to recognize problems which are common to the industry or segments of the industry, and to mount action programs leading to the solution of these concerns. Because of its broad representation and its reputation for constructive action, EIA is nationally recognized as the spokesperson for the electronic industries.

Membership

EIA membership is open to firms who manufacture, distribute, or produce electronic products in the United States. Certain other organizations may be admitted as Associate Members.

Administration

Broad EIA policy is established by a Board of Governors whose members are elected by the various Divisions of the Association. The EIA Executive Committee oversees programs delegated to it by the Board. An experienced professional staff of about 140 persons, headed by a salaried President, serves EIA from a headquarters building located in Washington, D.C., four blocks from the White House.

Organization

Organized along product lines, EIA's Groups/Divisions are the action centers around which most of the Association's work revolves. They provide the concentrated and specialized attention required by the issues facing the electronic industries, particularly the interface with legislative and regulatory bodies on the federal and state levels. Each Group/Division has its own mandate and objectives, its own Board of Governors, and initiates its own agendas. Each implements its own activities to meet the needs of its industry. Association members may belong to as many Groups/Divisions as appropriate to their product lines. Groups/Divisions include: Consumer Electronics; Industrial Electronics; Components; and the Government Division.

EIA Departments provide services in marketing statistics and other data, engineering standards, legislative and regulatory information, government relations, and public affairs. Services and programs of a broad nature which benefit the entire industry are also provided to the EIA membership through Board of Governors-sponsored programs. The services of all EIA Departments, Councils and Panels, as well as the administrative, legal, accounting and production services of the Association, are accessible to each Division.

Division Membership Dues

Companies join one or more Divisions of EIA, depending on their electronic product lines. Division dues are assessed as a small percentage of the annual sales value of these products for the preceding year. These dues, which are decided upon by the Division membership, are used to defray Division operating expenses, including Engineering and Marketing Services Department programs.

Basic Membership Dues

Each company is also assessed Basic dues, calculated in the same manner as Division dues, to support the Basic Services provided by the many Board-sponsored Councils, Panels and Committees which carry on EIA-wide programs of benefit to all members. Basic dues are also used for Association overhead and general and administrative expenses.

Meeting Activity

EIA holds two Association-wide, four-day conferences each year: In the spring in Washington, D.C., where the emphasis is on government relations; and in the fall on the West Coast. Most of the detailed work of the Association is conducted by more than 500 Councils, Panels, Sections, and Committees. These groups meet as necessary throughout the year, but carry on much of their activity by mail in order to minimize participation costs for members.

Information Programs

EIA provides its members with a wealth of information through regular publications and numerous special bulletins.

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memoranda, analyses and reports. These include various federal agency dockets as well as other federal regulatory and legislative proposals; analyses of military, space and other government budgets; and statistical marketing reports. EIA basic publications include:

- Annual Report
- Electronic Market Data Book
- Electronic Market Trends
- Electronics Foreign Trade
- Engineering Report
- Executive Report to the Electronic Industries
- Index of EIA and JEDEC Standards and Engineering Publications
- Publications Index
- Source and Date Code
- Trade Directory

There are many membership options available to prospective member companies, such as sizeable introductory discounts for the first two years of membership, the option of having only parts of a company belong to a Division of EIA, and Basic only membership. Further information on membership options, dues schedules and participation in EIA, should be requested from Membership Information EIA, 2001 Pennsylvania Avenue, N.W., Washington, D.C. 20006-1813 or by calling (202) 457-4004.

EIA MEMBERSHIP PROVIDES:

- **Government Agency Liaison**—EIA maintains close liaison with the rising number of government agencies—both defense and civil—which interface with the electronic industries. EIA develops and presents industry consensus views and recommendations as these agencies develop regulatory policy, regulations, and standards. Our primary goal is seeing that such government activity is reasonable as well administratively and technically feasible.
- **Congressional Liaison**—EIA monitors legislative activity having potential impact on the electronic industries and develops and presents testimony when congressional public hearings are scheduled. EIA is recognized by Congressional Committees as the spokesperson for the electronic industries.
- **Market Data**—EIA's in-depth marketing statistics provide information of great value for market planning by industrial companies.
- **Industry Product Standards**—EIA develops electronic component and product standards that are utilized by the industry as guidelines in product design, production and procurement. EIA also provides effective liaison with other standard-setting bodies.
- **International Aids**—EIA takes action to develop industry views regarding a wide range of international areas, such as foreign trade, nontariff trade barriers, international marketing and international standards.
- **Planning Material**—EIA brings together leading industry planners to study the significant issues facing the industry and to develop valuable material for future planning.
- **Home for New Technologies**—EIA recognizes new technologies and provides them with the services they need for stable growth within the industry.
- **A Meeting Place for Industry**—EIA regularly provides a forum for industry executives to keep abreast of and constructively involved in the constant changes affecting the industry.
- **Media Liaison**—EIA is the recognized information authority, in constant touch with national and trade press on current industry issues and queries.

The EIA Marketing Services Department

The EIA Marketing Services Department has long been recognized as THE AUTHORITATIVE SOURCE for statistical and analytical market information on the electronic industries. Information is provided through market activity reports, surveys and special reports, publications, the Marketing Services Research Center, market analysis, and liaison activities with other associations. The main function of the EIA Marketing Services Department is as a service arm, supplying statistical information to the EIA membership. The Department remains committed to developing new services and improving its current ones in an effort to meet the market information requirements of the fast-changing electronic industries.

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- Top 10 foreign suppliers of electronic products to the U.S.
- Top 10 data contain year-to-date statistics for over 300 eiectronic products by unit sales and dollar volume.
- Bilateral electronics trade data for the top 10 U.S. electronics trade partners.
- Import statistics for articles traded under Generalized System of Preferences (GSP) by product group.

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The monthly authoritative source for economic information and analysis on the U.S. electronics industry, including coverage of shipments, trade, employment, imports, exports, key economic indicators, and producer and consumer price indices. Tables and graphs are supplemented with summary trend interpretation.

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Fast Facts information packets offer current market overviews on some of the Research Center's most "popular" topics, including: Camcorders, Digital Equipment, Home Theater, CD Players, and U.S. Consumer Electronic Sales.

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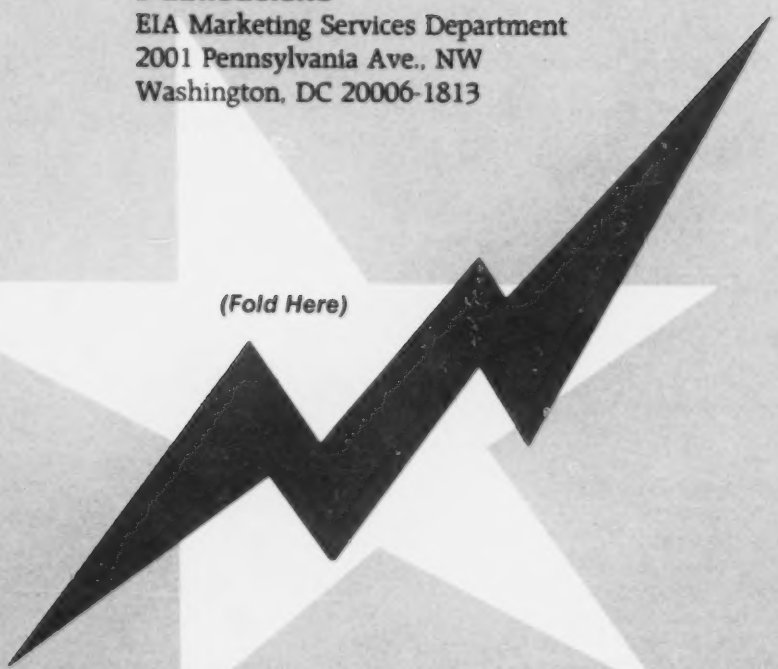

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